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SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXXVI]
NUMBER 2223]

NEW YORK, AUGUST 10, 1918

[10 CENTS A COPY
$5.00 A YEAR

From the Illustrated War News

A British gun at work on the Somme

SENDING THEM OVER THE TOP

Ports and Terminal Facilities—I*

Neglected Economical Problems

By R. S. MacElwee

THE port problem is a railway problem even more than a ship operating problem. It should be one of the three links of transportation—railway, port, ship—but the railway end of the trilogy is the one which has been most neglected and the one which has broken down under the strain of the war demands on transportation.

The problem is a serious one. If there be no quick dispatch of railway cars at the marine terminals the inland transportation system of the country will be paralyzed and we will have no coal nor many other things. We are sore pressed for ships, but if, because of the inefficiency of the ports and the railways at the ports here and in France, we turn the ships around only fast enough to allow a round trip every 12 weeks instead of every six weeks, the result is the same as if the Germans had torpedoed half of the existing meagre tonnage. On the other hand, if we are able to coordinate and operate the terminal ports here and in France so as to turn the ships around quickly and make the round trip in six weeks instead of 12, we have doubled the efficiency of our present merchant shipping without having built another ship. The port problem is as important a war measure as the ship problem.

Also, after the war, struggle for the markets of the world will be fierce. Any "*frais parasites*," any practical expense at the terminals, will act as an increased cost of production of American goods. Transportation is just as much a cost of production as raw materials or labor. If we are to hold and enlarge the markets for American goods, which will mean smoking chimneys and full dinner pails for American workers, we must scale down the unnecessary costs. Low wage costs do not mean low wages. Low wage costs per unit of product mean increase in the productivity of labor. Investments in terminal facilities do not mean higher costs per ton of traffic.

The port is one point where the unnecessary costs of production of American goods can be scaled down. Just as in the design of an aviation motor or of an aeroplane, the way to make the machine light is to reduce the weight a little here and a little there. There is no short cut. One little saving added to another little saving will in the end make a large difference in the weight of the motor and also in the cost of putting American products on the markets of the world. This is our only hope to meet the competition of many lands which in the past have been at this sort of thing more intensely than we. In particular, so far as inland water transportation and port development are concerned must we turn to the illustrious enemy. The great French engineering paper, *Le Genie Civil*, has been preaching this point constantly during the past two or three years. *Le Genie Civil* takes the stand that it is a peculiar kind of patriot who thinks it is unpatriotic to learn all that can be learned from the enemy. Such a patriot should be watched.

The port and terminal problem is one for both engineers *and* economists. There has been no real cooperation between the two sciences in the past. There has been a tendency to build wonderful piers as engineering structures which do not link up with the rest of the system and there has been port planning which would not stand up because of the engineering deficiencies. The day and age has arrived when there must be a new profession of engineer-economist to solve involved transportation problems, just as the patent attorney must be a lawyer and an engineer. The building of efficient ports will require the best engineering talent in the land. Americans can build, judging from the achievements on the Great Lakes, where bulk cargo loading transport and unloading have far surpassed any like achievement abroad. Our American engineers are more than equal to the task if given conditions which are right. The failure of our American ports in this crisis is not due to the engineers. The forces at fault are far less conspicuous and far more elusive; the failure of American ports at the present time is due to the peculiar conditions of American railway history—in particular, the competition of rival lines at the terminals. A new era in American railroading is dawning, and it is for this new era that we must plan. Planning and execution will require engineering-economists.

At the very beginning of the problem we must note what may be called the reservoir principle. The system of transportation from an American factory to a foreign consumer is composed of many movements, each distinct, each part of the whole. Transportation over rails, carts, piers, ships, etc., involves a series of distinct movements, each complete in itself. These separate movements cannot be entirely synchronized. The result is that one movement does not keep pace with the other. Where the joint occurs there is either lost motion or congestion. It is like the internal-combustion engine which develops power every fourth count or every second time the fly-wheel turns over. That is why there is a fly-wheel: to take up the power when it occurs and carry it over the dead centers. In a transportation system there is the same sort of intermittent motion along the route. With the exception of belt and bucket conveyors and pipe lines, there is no continuous movement. Continuous movement is the ideal to which freight handling aspires. Therefore fly-wheels or reservoirs must be devised at the terminals of each intermittent movement to take up the load and hold it until such time as it may be carried farther. The fewer the number of cylinders the larger the fly-wheel. The greater the irregularity of ships, freight trains, or canal barges entering a port, the more provision must be made for carrying the load over the dead centers. For instance, the ore and coal stock piles at the steel works on the Great Lakes must carry over a five months' dead center of frozen navigation, while our cities cannot exist five days without coal.

The two great reservoirs are the *warehouse* and the *transit shed*. As subdivisions of these two units there are many minor points where reservoirs are necessary, such as the point of deposit of freight transferred from the hold of the ship to the wharf. Freight must not "hang" for lack of place to set it down. There are also points of deposit for loading carts or freight cars or barges or lighters.

There is no blanket expedient; no panacea; no cure-all. Each point must be discovered in the particular system, and each case solved on its own demerits.

The railroad problem is too complex and at present in such a state of flux that it is beyond the scope of this paper to enter into the discussion. There are certain fundamental principles which must be stated, however, before it is possible to go on with the consideration of a few details.

With equal facilities for handling and equal port charges, the port with the widest choice of transportation facilities to the interior will be the greatest port. These facilities include the waterways. The largest ports of Europe are the ports at the mouths of great navigable water systems: Rotterdam on the outlet of the Rhine and Meuse systems; Hamburg on the Elbe-Oder systems. Antwerp is the port for the Scheldt and Belgian-French canal and waterway systems. Inland water navigation is important to the port. Nevertheless, even in the case of the highly developed German waterways two-thirds of all the tonnage travels by rail. The ports mentioned are great because there is a large *choice of connections* with the interior. It is not waterways *vs.* railways, but waterways *and* railways which make the port attractive to shipping. Many connecting lines act as the increase in the number of cylinders which makes a motor run smoothly.

If the port with the best prospects is the port with the most connections by rail and water with the interior, it follows that there must be *equal*, *universal*, and *free* movement between any pier and any railroad line. To this must be added universal connection with any warehouse.

A port must be a unit in respect to all its terminal facilities. Although far from being an ideal port, New York has grown beyond all other ports because of this universality of railroad connection. The complete harmony between every ship and every rail line is accomplished by so-called "free lighterage." Even at a high cost the advantages of the coordination have been so great that the expense of lighterage and the freight rate differentials have been offset by better service and the port has prospered. Other ports of the North Atlantic have been railroad terminals in the narrow sense of terminals for one railroad. The railroad has considered that the pier and then the ship berthing at the pier is a part of the private system of the railroad company. There have been no terminal charges against the freight in this case, and the ships are given free wharfage at a railroad pier. Free wharfage does not begin to offset the fact that the ship line has access only to the narrow hinterland served by one railroad system.

The principle that a port must be one zone with equal charges to any part of it has been upheld by the Interstate Commerce Commission. It has been argued against the separation of terminal charges from the line haul that European hotels may charge guests for candles and soap, but this is not the American plan. The comparison limps. We have yet to find a first-class American hotel which includes the wine bill in the room rent. With terminals operated as a unit there must be a separation of charges. *There must be physical connection between every pier and every railway and every warehouse at a uniform charge.*

How is complete flexibility between piers and railways accomplished? The belt railway is the solution. There are two kinds of belt lines: the outer belt line, which connects the railroads before they enter the port area, and the inner belt line, which connects the piers with each other, with the outer belt lines and with the main lines. It has been contended in hearings and in the press that New York does not need a harbor belt line, because the waters in the harbor serve better than any belt line could do. Universality is accomplished by the lighterage system, and this has helped to make New York great. Now is it peculiar to the port of New York that the harbor has water in it? There is not quite so much water at New Orleans, Montreal, Hamburg, Manchester, and elsewhere, but San Francisco has even more water than New York. Yet these ports have belt lines. We Puritanical Americans are inclined to look at everything from the moral standpoint: that it is either all good or all bad, either black or white. There are no shades in between. There may or may not be gradations between good and bad in morality, but in port development there are all sorts of things which taken together make a good port. No one thing will do it.

The function of the harbor belt railway is to enable carload freight to come directly to the pier-shed without rehandling. As will be discussed later, this does not mean that lighters are to be abolished. On the contrary, harbor lighters, both large and small, are a most neglected asset. The economic waste to be eliminated is opening a car and transferring its contents to a lighter to be towed to a ship when the car should be switched to the pier shed over a belt line, to be unloaded into the pier-shed to await the arrival of the ship. Note that it is never considered for a moment to load a ship directly from the cars. There are exceptions in the case of large and heavy pieces which should be brought alongside on gondola or flat cars. However, this is a small proportion of all the miscellaneous cargo of all the ships. A recent high port authority and also a metropolitan daily with an editorial writer of renown on these subjects have argued continually that ships cannot be loaded from railway cars directly, therefore why have a belt line at all? No one intends to load from the car to ship as a regular routine. Rehandling is the expensive part of freight movement. Towing lighters and switching cars are small items of the total. For instance, in handling carload freight in New York the switching costs in New Jersey are 10 cents a ton, out a total of $1.25 a ton for delivering the carload to New York, This is for a 20-ton load average, or $25 the car. This figure is only payroll expense and includes nothing for the investment. The belt line eliminates several of these expensive handlings of carload freight.

The best American example of a belt line is at Montreal. Here the car is switched from any rail line to any pier at a flat rate of $5 the car. For the year 1916, out of total receipts of $375,000 there was a profit of $100,000 from the belt line service. The belt line does a local drayage service for all private warehouse and industrial plants located on spur tracks of the belt line at a flat rate of $2.50 the car.

Also at New Orleans the belt line has been a success.

At San Francisco the same institution has shown the same success. For some time there was a link missing in the belt, and it cost about $12 a car to car-float around the missing link. This service was done by a railroad company, which collected accordingly. The incident brings out another axiom: "*A belt line, to be a success and give universal coordination between every pier or warehouse and every railway, must be entirely under one management and perform the switching service anywhere at one flat rate to all.*"

At Hamburg the harbor railway has a total length of tracks of 185 miles. For less than carloads, minimum 5 metric tons, the belt line charges are about ten cents per 100 pounds. For carload it is 1½ cents, and, to discourage the use of wharf sheds as far as possible, the charge is only three mills per 100 pounds when the transfer is direct from ship to car and the cars are moved at once.

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*Presented before the Engineers Club of Philadelphia, and republished from the *Journal* of the Club.

Before mentioning various successful port institutions at home and abroad, we may reiterate that port planning involves the establishment of two main reservoirs, the pier-shed and the warehouse, with a completely flexible universal connection between them and all vehicles by land and water. Keep constantly in mind *flexibility of physical connection and reservoirs*, to be sure we are talking about the same thing. We may define a port as harbor *plus* terminal facilities.

A railway and ship-line map of the world will show the obvious fact that the centers of densest railway nets are connected by the most ship lines. Western Europe and Eastern United States are the first great nets connected by the North Atlantic "Ferry." The third greatest railway net is the La Plate district of South America. A large bundle of shipping lines connect it with the other two. Ports widely separated compete with one another for the commerce of the hinterland. There is usually a more or less clearly defined economic drainage basin which discharges through a given port. Rotterdam has the Rhine Valley, Hamburg the Elbe-Oder, Antwerp all of Belgium and Northern France. Antwerp economically could not possibly be a German port. New York competes with New Orleans and with Montreal. A glance at a map showing the movement of wheat from the "Head of the Lakes" will show that New York, Philadelphia, and Baltimore compete successfully with Montreal, in spite of the excellent management and equipment of that port. *The reservoir factor of Buffalo*, with its eighteen or more great elevators, takes up the sudden thrust of the harvest during open navigation on the Lakes and gives out the grain again in an even flow during the time that Montreal is frozen shut. The port with the best facilities and the cheapest movement combined will extend its hinterland. The greatest known efficiency in bulk cargo handling is on the Great Lakes. Ore and grain come down and coal goes up. The Lakes likewise offer a two-way haul and no empties.

The efficiency of the Lakes is due to complete harmony between boat, pier, and railroad car. The Lake boat is all hatches. I counted 38 hatches on one boat last summer. These hatches are 12 feet between centers. The ore pier has a row of pockets or bins, each 12 feet wide, which are filled by 24-foot cars from the mines. Boat, bins, and cars all register. The bins hold 350 tons. When a boat comes alongside with all its hatches open, a chute from each bin is lowered into each hatch and the sluices open. The record for loading 10,000 tons of ore is 24 minutes. The great Hewlette "Grasshopper" unloaders with 15-ton grab buckets will unload such a boat in less than three hours. In 30 years the unloading costs have been reduced from 56 cents to four cents per ton. The per ton mile cost of transportation is one-half of one mill.

The efficiency of a port is not its size. A map illustrating the "Biggest-in-the-World" idea in the case of New York shows a map of New York occupying one-half of the page. Drawn to the same scale, the ports of Hamburg, Rotterdam, Liverpool, London, Amsterdam, Bremen, and Antwerp all together occupy the other half. This is a very poor commentary on the efficiency of New York. It does indicate the size of the problems confronting our greatest gateway, but when each of the other little dug-out-of-the-mud ports, without breaking down, have handled almost as much commerce as all of New York, then there must be something wrong on this side with New York. Several European ports, notably Marseilles, yearly average over 500 tons of cargo transferred over every linear foot of equipped quay, as against 150 tons at New York.

For the sake of knowing what we are talking about, attention must be called to the use of the word *dock*. There are no docks at Hamburg, but open tidal basins. At Bremen, Antwerp, and London there are docks.

The docks of London were dug out of the river banks. Owing to the tidal variation of about twenty feet the water in the basins was shut off from the river to maintain a constant level. A dock is a basin locked off by water-gates from the changes of tide or water level of the river or harbor. The expression "to dock a ship" has been corrupted to mean berthing a ship anywhere, and, finally, to mean the structure to which the ship is berthed. Thus a perfectly good pier, wharf, or quay is incorrectly called a dock. This leads to endless confusion, just as it does to use the word *gun* when one does not mean artillery at all, but a rifle.

Antwerp, before the war, had planned one of the greatest digging efforts, but the port of Antwerp suffers from the conflicting municipal and state authorities The plan was afterward abandoned. The idea was to dig a canal, called the Grand Coupure, across the bend in the Scheldt and then construct a lock canal several miles long, with nine basins, 2,500 to 3,500 feet long and 300 to 400 feet wide. These basins were to be added as the demands of commerce required, and were to be fully equipped with cranes, sheds, spur tracks, and upland for classification yards, warehouses, and industrial development. The old basins, some dating from Napoleon Bonaparte, are small affairs in comparison.

Bordeaux also intended to build a dock harbor on the locked canal and side-arm-basin principle. This has been commenced. The structures, which look like piers, are not piers in the American sense, but tongues of land several thousand feet long, faced with masonry quay walls. Pile structures are not practical in such large units.

Manchester, the inland town which became a port, has docks and quays. The longest docks are 2,700 feet by 300 feet. It seems that in Europe whenever a harbor is dug out of the ground the quay system and not the pier system prevails. Most of these harbors are dug out of low-lying marsh land, and the spoil of the dredges is used to fill the land to a sufficient height for building construction.

Tilbury docks, London, are an excellent example of the dock harbor and the artificial basin. There is a tidal antechamber or waiting basin and locks through which a ship passes into the constant level water of the dock. The dock consists of a turning basin and three slip basins of 300 feet width between two filled piers 1,600 feet long. These piers carry spur tracks at each edge and down the center, and four transit sheds on each quay. Back of the piers are the railway classification yards.

The reason of the narrow pier is historical. The city or state had title to land under water at the extension of the streets, and the pier was therefore no wider than the street of which it was an extension. The piers were large enough for the ships at the time they were built. This is no reason for retaining the narrow pier system for large modern ships.

The vexing question of the width of piers includes the factors of tacks, of cranes or other transfer machinery, and the question of the amount of cargo which the pier will be required to hold.

In the first place, the pier-shed, *unencumbered with teams, railway tracks, or other obstructions*, must be large enough to hold without crowding the entire cargo of the largest ship using the berth. An analysis of the most successful ports shows that at least 10 square feet per measurement ton of cargo has been the practice. The floor space is what counts, as there is great loss of effort in tiering more than shoulder high in a transit shed where the freight remains only a few days. We must keep clearly in our minds that the pier-shed is a reservoir to collect and hold the cargo for a ship until the ship is loaded, or to receive the cargo of the ship as fast as the ship can be unloaded and hold it until the goods can be taken away to the warehouse or other destination. Cargo must be assembled before a ship arrives at its berth in order to have it classified as to port of destination and for proper stowing.

Also, cargo must be gotten out of the ship as rapidly as possible in order that the ship may load and leave again. All this requires much handling. This handling requires elbow room. Ten square feet per ton of cargo of the largest ship is the minimum space to allow. This would mean a shed 1,000 by 150 feet for 15,000 cargo tons. It has been found that a better dimension is 750 by 200 feet. This seems a very wide shed to most of us, but this is the dimension of the most recent layouts abroad, at ports which have found the other sizes inadequate.

For short distances not over 200 feet there is no substitution for the hand truck as to flexibility. It is quicker to run across the pier from the hatch than along the pier.

Above everything, freight must not be allowed to "hang" in the ship slings while unloading. It *must* be gotten away as fast as it comes out. To prevent "hanging," stevedores are kept waiting. This is a loss.

There has been much talk about eliminating the hand truck. The hand truck cannot be eliminated. There may be devised many helps and aids for the longer haul. The hand truck becomes uneconomical above a certain distance of 150 to 200 feet. It is then worth while to pick up the load by mechanical means for a longer haul. There is the electric truck for this purpose.

The electric truck requires skilled attention and smooth pier deck.

The telfer requires a heavy superstructure and skilled operation. The possibilities of both electric and telfer are great.

Particulary promising is the removable body in connection with the telfer and the system of store-door delivery. This system uses the hand truck or lurry for short movements to within reach of the telfer. The loaded lurries are picked up bodily and carried to the waiting motor truck chassis, which are built to carry two each. The inauguration of store-door delivery by zones with pooled terminal facilities should make the telfer and the removable body practical. Also, the dray would be banned from the pier-shed, where it is such a nuisance.

[TO BE CONTINUED]

The Minimum Radiation Visually Perceptible

CALCULATIONS have been made of the minimum energy required to excite the retina to visual perception. Evidently the minimum energy required will depend upon surrounding conditions. For example, a sixth-magnitude star is considered the limit of vision in viewing stars. When the eye is adapted to complete darkness its sensibility is much greater than when viewing a star.

Assuming that a sixth-magnitude star is the limit of visibility (at sea level) of the central retina and that the pupillary opening is 3 mm. in diameter, Drude calculated that the eye would respond to 12×10^{-9} candles, *i. e.*, a sixth-magnitude star is as bright as a Hefner flame at 11,000 meters. The total radiation from a Hefner flame is 26×10^{-6} g-cal. per cm² per second (29×10^{-6} for a sperm candle) at 1 m. The radiant luminous efficiency of the sperm candle is 0.0024, so that for the Hefner flame it is about 0.0027. This gives a value of 7×10^{-8} g-cal. (or 29×10^{-5} watt) per cm.² per second for the luminous energy density at 1 m. For a pupillary opening of 3 mm. and a candle at 11,000 meters the light intercepted by the eye would be $(29\times10^{-6}\times0.07 \div 11{,}000^2 =) 1.7\times10^{-16}$ watt $= 1.7\times10^{-9}$ erg. per cm.²

The sensitivity of the eye may be estimated also from direct measurements of the heat from stars. The calibration of the radiometer was 1 mm. deflection $= 34\times10^{-14}$ g-cal. per cm² per minute $= 85.5\times10^{-16}$ watt per cm² per second. The sixth-magnitude stars gave deflections of 0.5 mm. for blue stars to 1.5 mm. for red stars (say, 1 mm. on an average), depending upon their color. From measurements made on the transmission of stellar radiation through a cell of water the radiant luminous efficiency may be 0.2 (0.1 for red stars to 0.4 for blue stars. Hence, the luminous energy intercepted by a pupillary opening of 0.07 cm² is $(85.5\times10^{-16}\times0.2\times0.07 =) 1.2\times10^{-16}$ watt or 1.2×10^{-9} erg., which is in agreement with the preceding computation.

Another method of estimating the minimum radiation which is visually perceptible is to use data on the mechanical equivalent of light, viz., 1 lumen per cm² $= 1.6\times10^{-7}$ watt per cm.² A pupil opening of 3 mm. will intercept $(0.07\times1.6\times10^{-7} =) 1.1\times10^{-8}$ watt and for 1.2×10^{-8} meter candle this amounts to 1.3×10^{-16} watt or 1.3×10^{-9} erg.

These computations show the extraordinary sensibility of the eye as compared with a radiometer, which had to be combined with a 3-foot reflecting mirror in order to attain the same sensibility. The ratio of the area of the mirror to the radiometric receiver was 1 to 7,000,000. In other words, the eye is 7,000,000 times as sensitive as the radiometer receiver used two years ago to measure heat from stars. Recent improvements in the radiometer reduce this value to about $\frac{1}{100000}$ as sensitive as the eye.

As a further illustration of the extraordinary sensibility of the eye, the above calculations show that it responds to visually perceptible energy of the order of 1.3×10^{-16} watt (3×10^{-14} g-cal. per minute), at which rate it would take 60,000,000 years to raise the temperature of 1 gram of water 1°.

Since writing this paper Dr. Burns has called our attention to a very interesting paper by H. D. Curtis on the limits of unaided vision. One difficulty of making the test of star visibility is in finding the position of the star, after which it is comparatively easy to recognize it. Another difficulty arises from the fact that the background of the sky is not perfectly dark. Given as artificial aids the direction in which the object lies and the screening off of the light of the sky (by looking through a long tube), Curtis could easily see stars of the 7.5 to 8.0 magnitude, but stars of the 8.3 to 8.5 magnitude were seen with difficulty. This means brightnesses one-fifth to one-sixth as great as used in the above calculations. The pupillary aperture would be 6 to 7 mm. Using these values, the above computations give about $8\times10.^{10}$ erg., which is a reasonable estimate of the sensibility of the eye.—From a paper in *Bulletin of the Bureau of Standards*, Vol. 14, No. 2 on Relative sensibility of the Average Eye to Light of Different Colors and Some Practical Applications of Radiation Problems, by W. W. COBLENTZ and W. B. EMERSON.

Value of African Timber Now Recognized

IT is not so very long ago that South African timber was, taken all round, considered of little value. Now that imported timber has gone up in the market, according to *South Africa*, many virtues have been discovered in the native timber which previously were unknown. In consequence South African timber has come to the front, so that it figures prominently in many issues. Sawing timber, such as Cape pine, poplar, yellow wood, blue gum, and other varieties, cut into standard deals of 3 inches by 9 inches, is quoted at 10½d. to 1s. per foot. This timber is mostly used for boxes and packing cases, as well as substitutes in the mines and buildings for the imported Baltic and Oregon woods. —*The Engineer*.

Anomalies in the Animal World—Part XII

Anomalies of the Senses in Fishes

By Dr. R. W. Shufeldt

FISHES possess all the special senses that are found to be present in the higher groups of animals, man included. The sensory organs that preside over these senses vary enormously in the matter of their structure throughout the Class, and with these differences their physiology likewise varies *per se* with the variation in the morphology, though the *function* of the several organs is the same. For example, the eyes in fishes exhibit great variation in their morphology, and this, in some instances, may cause slight variation in their physiology, while the *function* of all eyes is to preside over the sense of sight.

Throughout the vertebrata, all the sensory organs are formed from differentiations of the skin or integument. Fish possess an organ that it devoted to the sense of *hearing;* they have a nasal organ which ministers to the sense of *smell.* When they have not degenerated from any cause, they have eyes through which they enjoy the sense of *sight;* and many kinds of tactile organs by which the sense of *touch* is appreciated. That fish are also capable of *tasting* there should be no reasonable doubt, as the presence of certain goblet-shaped organs in the mucous membrane of the palate, in certain species, seem to have developed there for that very purpose. Schulze has demonstrated the presence of these organs in *Tinca.*

Here, then, are at least *five senses* that are present in an ordinary fish, as for example a carp. To these there are doubtless to be added others, as the sense of reproduction or the *sexual* sense, which in some forms is most powerfully developed, as may be noted during the spawning season. Anatomists and physiologists have long suspected the presence of still other senses, and with respect to these, a great German authority once expressed himself as follows: "There are many organs which can be reckoned among the known specific sensory organs, but which are remarkable for the high grade of their differentiation, so that their arrangements do not allow us to regard them as mere 'tactile organs'; these seem to justify us in assuming the existence of specific sensory organs other than those known to us familiarly."[1]

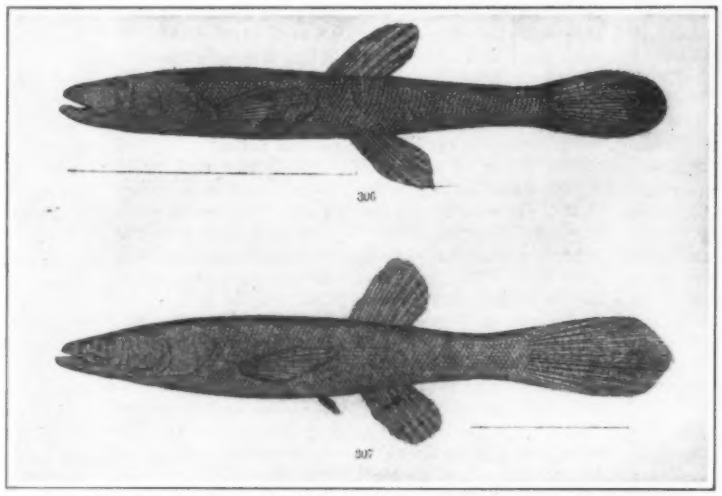
Jordan and Kellogg have stated that "The study of the special senses presents two phases, namely, the study of the structure of the organs of special sense, and the study of the physiology of special sense—that is, the functions of these organs. It will be recognized that in the study of how other animals feel and taste and smell and hear and see, we shall have to base all our study on our own experience. We know of hearing and seeing only by what we know of our own hearing and seeing; but by the examination of the structure of the hearing and seeing organs of certain other animals, and by observation and experiments, zoologists are convinced that some animals hear sounds that we can not hear, and some see colors that we cannot see.

"While that phase of the study of the special senses which concerns their structure may be quite successfully undertaken, the physiological phase of the study of the actual tasting and seeing and hearing of the lower animals is a matter of much difficulty. The condition and character of the special senses vary notably among different animals. There may even exist other special senses than the ones we possess, a 'density of pressure sense'—that is, a sense which enables them to tell approximately how deep in the water they may be at any time. To certain animals is ascribed a 'temperature sense,' and some zoologists believe that what we call the homing instinct of animals, as shown by the homing pigeons and honey-bees and other animals, depends on their possession of a special sense which man does not possess . . . In numerous animals there exists, besides the organs of the five special senses which we possess, organs whose structure compels us to believe them to be organs of special sense, but whose function is wholly unknown to us."[2]

As a matter of fact, the study of the *senses* in fishes is still quite in its infancy; as yet we know but very little of the anatomy of the special organs in them, and still less of the physiology of those organs.

It has already been stated above that the eyes of fishes invariably preside over the special sense of sight; and yet in some species these organs present very singular anomalies. Although there are a few exceptions to the rule, as we shall see in a chapter further on, the eyes of fishes are intended to see beneath the water with, and, as in the case of the eyes in all animals, sight only becomes possible to the eyes of diurnal animals when there is light present. To be sure, there may be fishes that are nocturnal fishes, just as there are nocturnal mammals and birds of various kinds; but the majority of fish doubtless depend upon the presence of light, in order to see or use their eyes. Where the light is removed, and the removal persists for an indefinite period, it has such an effect upon the eyes of fishes that some of their descendants may within comparatively short space of time lose the sense of sight entirely.

Geology or physical geography teaches us that caves and caverns are, as a rule, formed by the erosion of underground rivers. These rivers, which are usually clear and cold, must somewhere come to the surface again, and when they do, fish that relish such water enter them from other streams. Sooner or later some of these fish—maybe a great many of them—get into the caverns, and finally swim into total darkness. Here their eyes become useless, greatly to their disadvantage in their struggle for existence. Some may escape from their predicament; but thousands of them, unable to procure food, eventually die, while still others, physically capable of maintaining life under such disadvantageous conditions, breed. The progeny thrive—though some die out—and none of them have any use for their eyes. So it comes to pass, in the ultimate generations—or in the descendants—that the eyes, which have been atrophying with each succeeding generation, finally become functionless, and the organs almost disappear. Such fish of the caverns and caves in time also become nearly white, as they, from generation to generation, gradually lose the color of their ancestors.



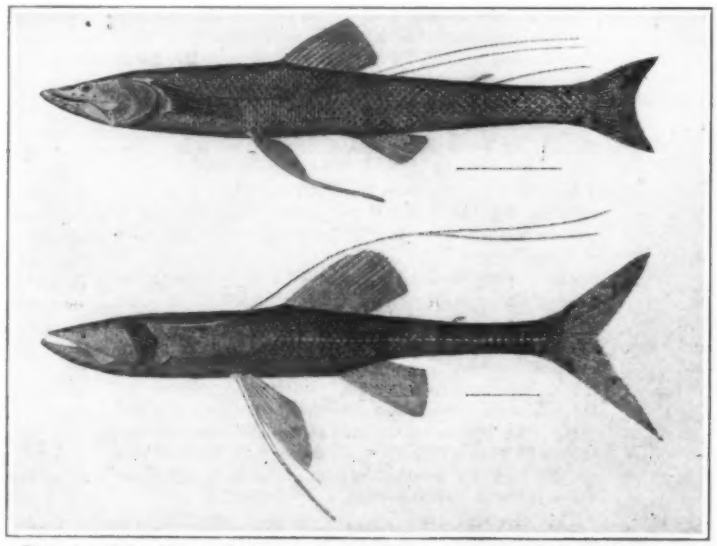
Figs. 1 and 2. Examples of blind cave fishes. Upper, known to science as Typhlichthys subterraneus; lower, Amblyopsis Speleus. By the author after Jordan and Evermann

It has been through such an involution as this that the small, "blind" fishes of the limestone caves—as the Mammoth cave of Kentucky, and similar, though smaller ones, in Missouri, Indiana and Tennessee—have come into existence and been described as *new species.* Ichthyologists have shown that the Dismal Swamp Fish, a conspicuously *colored species* with medium-sized eyes (*Chologaster cornutus*), is the ancestor of the blind fish, and among them Agassiz's cave fish (*Chologaster agassizi*) and the small blind fish (*Typhlichthys subterraneus*), found in the limestone caves mentioned in a previous paragraph. (See Figs. 1, 2 of this chapter.)

It will be appreciated, then, that this group of blind fishes, not only of America but of other parts of the world, is a very ancient one, for it has taken a great many generations of them to have become blind and had their eyes atrophy. In some species their rudimentary eyes can still be found *hidden under the skin.*

Some beautiful alcoholic specimens of these fish were shown me the other day by Mr. Barton Bean at the U. S. National Museum; they were no longer than my forefinger and almost white.

Up to the present time not more than half a dozen species have been discovered, and these are now referred to three genera. Doubtless a number of new species and genera will be discovered in the future, and the ranges of those now described extended. We may confidently expect that the little-explored caves and underground rivers of the West will furnish some new and interesting species.[1]



Figs. 3 and 4. Upper, Bathypterois quadrifilis; lower, Bathypterois longipes. By the author after Goode and Bean. Fish with extremely small eyes and with probably limited power of sense of sight

Some of the most remarkable fishes known are those which have been taken in dredges at great depths in the ocean. Further on, in a subsequent chapter of these articles, some of these will be described as the most extraordinary piscine anomalies that have come to the knowledge of science

Occasionally some of these "deep-sea fishes" possess rudimentary eyes, as there is but little or practically no light at the enormous depths at which they live. Such fishes are seen in Figs. 3 and 4, and they are extremely rare specimens. Of these *Bathypterois longipes* but few examples are in existence. The *Challenger Expedition* was fortunate in obtaining two of them off the coast of South America; each measured about nine inches in length, and were taken at the tremendous depth of 2,650 fathoms or 15,900 feet!

In other deep-sea fishes the eyes in their physiological effort to *gain* light, when the light is forever dim in their habitats far down in the ocean's depths, become larger and larger in succeeding generations. This is a very interesting fact and represents an evolution instead of an involution—the first an effort to maintain the function of an organ at any expense, and the second the gradual loss of it, and the production of a vestigeal structure of no use to its owner.

[1] GEGENBAUR, CARL. "Elements of Comparative Anatomy." London, 1878. Trans. by F. Jeffrey Bell and revised by Professor (now Sir) E. Ray Lankester, p. 523.

[2] JORDAN, DAVID STARR, and KELLOGG, VERNON L. "Animal Life, a First Book of Zoology." New York, 1902, pp. 224, 225.

[1] PUTNAM, F. W. Amer. Nat., 1872, p. 30 (Figure.)
COPE, EDW. D. "Life in the Wyandot Cave." Amer. Mag. Nat. Hist. Ser. 4, viii, 1871, p. 368.
GARMAN, SAMUEL. Bull. Mus. Comp. Zool. xvii, No. 6, 1889, p. 232.
These three most interesting and valuable articles contain a great deal upon the distribution and habits of the blind fishes of this country.

An excellent example, selected from many others representing numerous genera and species, wherein the eyes are of enormous proportion to the fish, is here shown in Figs. 5, 6, 7 (*Cyttus hololepis*). It is a species about eighty millimeters long, and has been taken at a depth of 220 fathoms. Many examples of these fish with prodigious eyes might be cited; but this specimen of *Cyttus* will be ample for our purpose.

Sometimes these deep-sea fishes with microscopic eyes are truly extraordinary looking creatures, having forms quite different from most ordinary species; they are fish known as Ceratiids, and there is a genus of them that has been named by the distinguished ichthyologist, Theo. N. Gill, *Mancalias*, of which there are two species known (1895). One of these, named Shufeldt's ceratiid (M. shufeldti), when first described by Dr. Gill was considered by him to have *no eyes*, and he therefore created for it a new genus which he called *Typhlosaras*. Subsequently, however, his artist, who made the figure here reproduced in Fig. 8, discovered the minute eyes of the species while engaged upon the drawing, and the form was finally relegated to the genus *Mancalias*, where it has since remained.

These ceratiids are deep-sea forms obtained at enormous depths in the Western Atlantic, and there have been but two specimens of *M. shufeldti* found. They occur in from 300 to 2,400 fathoms of water, and are small, very dark-colored species.

Goode and Bean (Deep-sea Fishes of the Atlantic Basin, p. 490), in describing *M. uranoscopus*, the other species of the genus, say that "The presence of a fish of this group at so great depth is of special interest. From its structure, and from the analogy of its nearest allies, there seems to be no reasonable doubt that it lives on the bottom. It is the habit of many of the family to lie hidden in the mud, with the long dorsal filament and its terminal soft expansion exposed. (See Fig. 8.) It has been imagined that the expansions issued as a bait to allure its prey; but it seems more likely that it is a sense organ, intended to give notice of their approach."

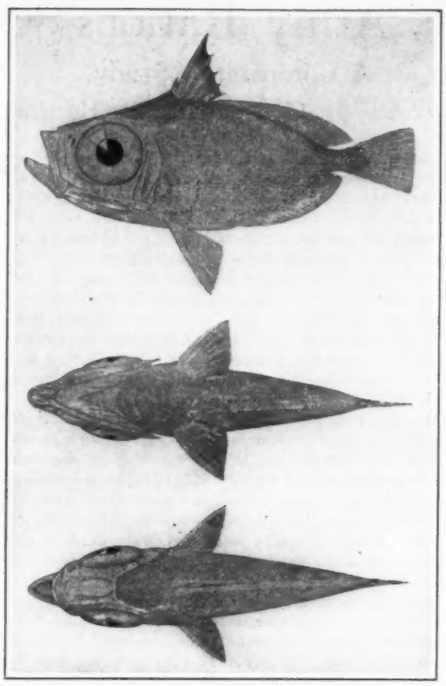
In the genus *Cryptopsaras* of Gill, we find other forms of ceratiids, more or less nearly affined to those of the genus *Mancalias*, and probably having the same habits. They also occur at great depths in the ocean, and possess very minute eyes.

Speaking of the eyes of fishes, there is probably no more anomalous species in this respect than the one occurring in the seas of the American tropics, known as the "four-eyes"; and the best known species of the several known has consequently received the scientific name of *Anableps tetraophthalmus*. These are cyprinodont fishes that have, in either eye, the cornea divided into upper and lower havles by a dark, horizontal stripe of the conjunctiva; and, what is still more singular, there are *two pupils* in either orbit. This arrangement lends to this fish the appearance of possessing four eyes, one pair of which look sidewise, and the other pair upward.

Have fishes, living as they do under water, the same sense of smell as have animals that live and breathe upon the land? It would surely appear that they do. In all vertebrates, the *sensory organ* in developing arises in the common integument, and this includes fishes; and, in tracing this organ, from fishes upward through the amphibians, reptilia, birds and mammals, it passes through the entire series, its structure only becoming modified in such a way as to adapt itself to the organization in which it occurs. Therefore, as we find it in fishes, we are compelled to consider it an olfactory organ, whether it has that function in them or not. Naturally, it is a far more complicated organ in the higher vertebrates than in fish, where it is found to be of a very simple construction—a fact, however, that may in no way militate against its being an olfactory organ.

Among the higer fishes (*Teleosteans*), the external narial openings, on either side, is a pit, over which a bridge of integument may be drawn. In some species these openings may be widely separated. Sometimes they present tubular projections, and the mucous membrane lining them is folded, thus considerably increasing the surface for the terminal sense nerves, which come, by branches, from the olfactory nerves.

There has been some very recent and excellent work done in this field of research, and none better than the experiments of Parker and Sheldon. In their Conclusions and Summary they state: "Whether such olfactory reactions as those that have just been described are really due to smell or not is regarded by some authors as an open question. Nagel, who has discussed this matter at some length, concluded on rather theoretic grounds that fishes could not possibly possess a sense of smell, and that their so-called olfactory organs act more as organs of taste than of smell. Possibly the whole matter is merely one of definition." After presenting some important comments on the sense of smell in animals generally, these authors conclude that "We, therefore, believe that the fishes, although water inhabiting animals, possess olfactory organs that are as much organs of smell as are the olfactory organs of the air-breathing vertebrates." The six *proved points*, arrayed in order under their Summary, record an advance in this question, the importance of which, as a contribution to vertebrate physiology, cannot well be overestimated.[4]



Figs. 5, 6 and 7. Three views of a deep sea fish with very large eyes (Cyttus hololepis). By the author after Goode and Bean

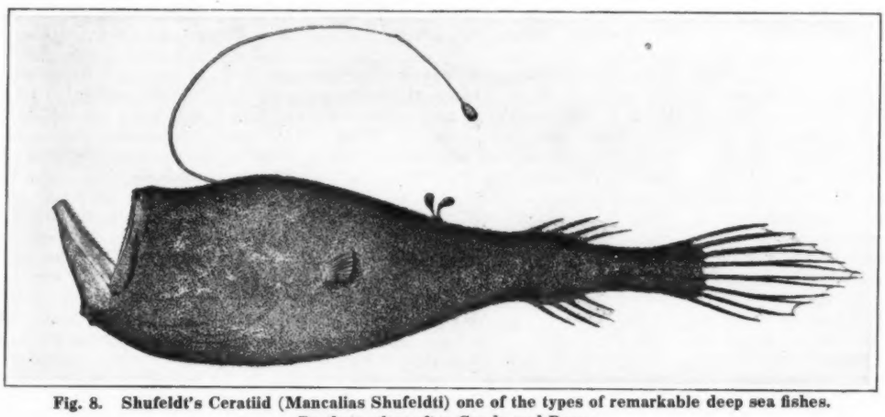


Fig. 8. Shufeldt's Ceratiid (Mancalias Shufeldti) one of the types of remarkable deep sea fishes. By the author after Goode and Bean

That fishes possess an auditory organ and can appreciate sound transmitted to them, either on land or under water, there is no question. Remarkable variations of the organ are found to exist, in the matter of anatomical structure, throughout the various piscine Classes, and in some interesting species these auditory organs are connected with the *air-bladder*. There is no *external ear*, however, and the structure as a whole is always much simpler than we find it to be in the higher vertebrates.

The curious white, free concretions we call "earstones," found in the ears of fishes, are the *otoliths* and they are sometimes very large. In addition they perform a concussive function and do not belong to the skeleton proper.

[4] PARKER, G. H., and SHELDON, R. E. "The Sense of Smell in Fishes." Bull. Bur. Fisheries, Vol. XXXII, Doc. No. 775. Issued May 3, 1913, pp. 35-46.

Other important papers on this subject are:

COPELAND, M. "The Olfactory reactions of the puffer or swellfish, Spheroides maculatus." Jour. Exper. Zool., Vol. 12, pp. 363-368, 1912.

HERRICK, C. J. "The Organs and Sense of Taste in Fishes," Bull. U. S. Fish Comm., Vol. XXII, 1902, pp. 237-272. Bull. Scientif. Lab. Denison Univer., Vol. 12, 1903, pp. 39-96. (3) "On the phylogenetic differentiation of the organs of smell and taste." Jour. Comp. Neurol. and Psychol., Vol. 18, pp. 157-166.

To these may be added the papers by Aronsohn, Baglioni, Field, Copeland, Nagel, Parker (G. H.), Sheldon (4.3), Sherrington and Steiner (J), all of which are cited in the above quoted paper.

Neon Lamps

NEON is a very curious gas, and very promising for the illuminating engineer. Although its atomic weight of 20.2 is intermediate between those of helium 4 and of argon 39.88, it has the lowest dielectric cohesion known of any gas, 5.6, while the dielectric cohesion of helium is 18.3 and that of air 435 (E. Bouty). Owing to this fact a very small electric potential suffices to set neon glowing; a glass tube containing neon need only be shaken to call forth the reddish glow, and when the gas is pumped from one vessel into another, the whole column shines. Its spectrum is most favorable for light effects the chief lines lying in the yellow and orange-red between 530 $\mu\mu$ and 650 $\mu\mu$. When G. Claude, of Paris, therefore, succeeded in preparing neon, or at any rate, mixtures of neon and helium commercially by liquefying air, neon seemed to be the ideal gas for illumination by means of glass tubes, many feet in length, after the method of Moore, who charged his tubes with rarefied nitrogen. The potential gradient in the positive neon column is only 1 volt per centimetre in wide tubes (a few inches in diameter) and Claude found that, in neon at a pressure of 1 mm. or 2 mm. of mercury, the fall of potential is inversely proportional to the width of the tube, and that on tubes of large cross-section a very small potential would suffice to sustain the discharge. The neon in the higher atmosphere, he suggested, might also account for the luminosity of the aurora borealis; with the enormous available cross-sections of the atmosphere very small potential differences would maintain a discharge through distances of many miles. The neon-tube lamps of Claude indeed evoked a great interest years ago. Little has been heard of them of late, however. Their reddish light is against them, and though they were popular for advertisement purposes, their use did not spread. There are great technical difficulties, moreover. Traces of other gases in the neon suppress the glow, and as air will force its way into vacuum tubes, the lamps deteriorated. To a certain extent the lamp cures itself; Claude observed that the metallic electrodes of his tubes gradually absorbed helium so that finally only the neon spectrum was visible; this may help to explain the hotly-contested statement made by the late Sir W. Ramsay and Messrs. J. N. Collie and H. S. Patterson (1913), that neon appeared after long use in hydrogen discharge tubes; speculations as to a synthesis of neon were based upon those experiments. But most impurities interfere with the glow, and that applies also to the metallic vapors and gases given off by the electrodes. Claude worked first with high-tension alternating current of low intensity, about 1 ampere. On low-tension direct-current circuits the lamps are arranged like the Cooper-Hewitt mercury-arc lamps. The anode of the recent lamps of Skaupy and others is made of a metal of low volatility (iron, nickel, tungsten), the kathode of a liquid metal or an easily-liquefied metal, to which the arc adheres. The vapors of the kathode metal must not be allowed to penetrate into the neon, and they are condensed by cooling or by providing buffer plates; when metals like the alkalis, thallium or cadmium are used, there is danger, moreover, not only that the metals will be deposited on the glass walls, but also that they will attack the silicon in the glass. Mercury itself has been found to be unsuitable as kathode material by Claude and by Cooper-Hewitt. Skaupy tried sodium which has the advantage of absorbing the residual gases. Fritz Schröter, first tried sodium amalgam, but later an alloy of cadmium and thallium. He obtains one candle at an expenditure of 0.27 watt, but the resistance brings the current consumption up to 0.5 watt. The neon lamp is started with the aid of a self-induction coil.—*Engineer*.

Army Rations*

A Comparative Study

By William H. Newcomb, M. D., Post Graduate Hospital, New York City

NAPOLEON is said to have remarked that an army marches on its stomach, signifying of course that in order to fight well, soldiers must be fed well and suitably.

It may be asserted, then, in connection with the above obvious statement, that the armies which are the best and most appropriately fed, other things being equal, will win the war.

Thus the saying that "Food Will Win the War" is absolutely true.

However, the fact must never be lost sight of, that races differ very widely in the kind of food which they consume and on which they thrive. Climate has a good deal to do with this, but habit is perhaps even of greater consequence. The English speaking peoples, or rather those of English origin, are, on the whole, the greatest consumers of meat in the whole world, although since Germany became prosperous, the Germans have run them fairly close in this respect. The quantity of meat consumed is a reliable index, to a great extent, of a nation's prosperity. The Australians *per capita* are the richest people on earth; and they are easily the greatest meat eaters.

With regard to army rations, the soldiers of this country are the best fed; but before dealing with the dietary arrangements of our own army, those of some of the other nations engaged in the war will be discussed briefly.

First, the rations of the German Army will be considered. According to Zuntz the average starvation metabolism of the resting German of average weight may be put at 1,700 large calories. The large calorie is the heat required to raise one kilogram equivalent to 2.2 pounds of water through 1 C. or 1.8 F. That of an infantryman doing a 25-kilometer march and carrying a 30-kilogram pack is 4,100 to 5,000 calories. Zuntz gives an infantryman's average weight at 63 to 67 kilograms, and his diet as follows in grams:

Meat 125, sausage 150, bread 350, yolk of egg 50, marmalade 50, butter 100, sugar 30, beer 1,793, brandy 20, mustard 1.

This diet affords 177 grams of fat, 100 grams of protein, 378 grams of carbohydrates, and 77 grams of alcohol. For a soldier four kilograms heavier, this diet, says Zuntz, must be increased, for example, 300 grams milk and 50 grams rice. The value of one gram of fat is 9.3 calories of protein, starch or sugar, 4.1 calories; of alcohol, 7 calories, the calorie worth of the lighter man's diet was 4,117; of the heavier, 4,481.

In the early part of 1915, the *Frankfurter Zeitung* stated that each German soldier got 1½ pounds of bread, ¾-pound of fresh meat, ½-pound of fresh vegetables or 3 pounds of potatoes, 65 grams of fat, 50 grams of cheese, 25 grams of salt, and 25 grams of coffee. In addition, each man got daily two portions of warm drink, coffee, tea, or cocoa, a special portion of sugar, 0.1 liter of cognac, arrack or rum, or an equal amount of tobacco or snuff. The calorie worth of this diet is probably over 4,500.

The Austrian Army diet in 1915 was given as containing 750 grams of bread, or biscuit equivalent, 375 grams of fresh meat, and 60 grams of fat, or the equivalent of these in dried or preserved meat, 250 grams of peas or rice or groats, or the equivalent in potatoes or fresh vegetables, 25 grams roasted coffee, 2 grams tea, 17 grams of sugar and half a liter of wine. For exceptionally strenuous work and bad climatic conditions, the coffee or the tea and sugar ration is doubled or 0.1 liter of spirits is given.

The war ration of the British Army during the South African campaign contained—protein 138 grams, fat 105 grams, carbohydrates 328 grams and had a value of 3,963 calories. In 1906, the average food supplied to four British regiments was found to contain—protein 133 grams, fat 115 grams and carbohydrates 424 grams with a value of 3,369 calories. The *British Medical Journal* March 20th, 1915, has an article in which it is pointed out that in Great Britain careful observations were made of soldiers marching and bivouacing as in war time in autumnal weather. These observations were carried out before the present war by the British Army Medical Advisory Board, and it was determined that the previous scale of war diet was insufficient to maintain the weight and condition and satisfy the appetites of the men. The value of the diet for war was then raised, chiefly by the addition of bacon and cheese, to 4,500 and 5,000 calories. The scale of rations of the British Army at the present time include 1¼ pounds of fresh meat or its equivalent in preserved meat, 1¼ pounds of bread or its equivalent in biscuit or flour, 403 of bacon, 303 of cheese, ½ cup of fresh vegetables or its equivalent in peas, beans, etc., ¼ pound of jam, 3 ounces of sugar, 2 ounces of butter twice a week, ½ ounce of tea, with salt, mustard and pepper, and 2 ounces of tobacco or cigarettes a week. The men in the trenches have as extras, pea soup, additional tea and sugar rations and ½ gill of rum at the discretion of the brigadier-divisional commander. The value of the whole ration is about 4,700 calories, not counting the extras. The rum ration is issued twice a week approximately to all ranks and an additional half-ration is supplied on each of the other days to the men in the trenches. During the very cold inclement weather a full ration of rum is issued daily to the men in the trenches; the full ration, half a gill, is 2½ ounces.

The late Col. Woodruff, up to the time of his death Associate Editor of *American Medicine*, writing on the subject of Army Rations in the *Journal of the American Medical Association*, Dec. 3d, 1892, worked out a table of comparisons in eight countries which was copied in Dietotherapy recently brought out by Major W. E. Fitch. Woodruff rightly holds that the rations of soldiers, to be of the greatest value, must be well adapted to climate.

The Japanese ration in the field consists of rice uncooked 30 ounces or steamed and dried 25 ounces, fresh bread 20 ounces, hard bread 13 ounces, meat canned 10 ounces or fresh with bones 13 ounces, which may be increased to 20 ounces if procurable. Salt, dried or smoked meat 8 ounces, vegetables, dry 8 ounces, or green 32 ounces. Pickles, sauces and condiments, tea and sugar, sake beer made from rice. The Japanese Medical Regulations provide that the nutritive value of the ration shall never fall below 2,580 calories. The scale of rations of the French Army is divided into three parts, reserve, strong and normal rations. The strong ration is the field or wartime ration. The French have fully realized that troops in the field require more food than those in the garrison, owing to the fact that in the field they undergo more physical exertion and mental strain. Therefore, the strong ration gives not only additional food but is extremely elastic and supple, according to "Dietotherapy" the composition of the strong ration of the French Army is as follows: Soft bread 1.65 pounds, field bread 1.54 pounds, hard bread 1.32 pounds, fresh meat 1.10 pounds, canned meat .66 pound, dried vegetables or rice .22 pound, salt 0.44 pound, sugar .0704 pound, coffee roasted, in tablets or loose, .0528 pound, coffee, green .0627 pound, lard, when fresh meat is issued, .066 pound. Potage salé, when canned meat is issued, .11 pound, brandy to each man in bivouac, or when specially ordered, .2641 quart, wine .5282 quart, tobacco, "caporal" for officers, .033 pound, "cantine" for enlisted men, .033 pound.

Authorized Substitutive Equivalents.—Substitutes for one ration of fresh meat, beef, veal, mutton, pork, rabbit, horse or fresh fish 1.10 pounds. Meat puddings, eggs, soft cheese .825 pound, cod-fish, salted, .66 pound, bacon .66 pound, smoked meat, herring, salted, or salted sardines .55 pound, cheese, Gruyère, Holland, Chester, Roquefort .55 pound, sardines in oil .33 pound, cod-fish, dried, meat powder .275 pound, cow's milk 2.6412 quarts, substitute for one ration of dried vegetables or rice .22 pound, of potatoes 1.65 pounds, turnips, carrots or cabbage, 2.2 pounds, sauerkraut 1.32 pounds, canned vegetables .264 pound, wheat flour .22 pound, Italian pastes, noodles, vermicelli, etc., .22 pound, cornmeal .22 pound.

The above list gives the substitutes which were allowed previous to the war. It has been greatly increased since. It is of interest to draw attention to the use that the French have made of dehydrated vegetables in their army during the past two years. In the first year of the war canned vegetables were imported for the soldiers. It was found, however, that not only could dehydrated vegetables be more easily transported on account of their very small bulk, but that they were more nutritious than the canned articles. The daily ration of the French soldier in war is—meat 14½ ounces, bread 26¼ ounces, or biscuit 21 ounces, vegetables dehydrated 1 ounce, butter 1 ounce, rice 2¼ ounces, sugar ¾ ounce, soup condensed ¼ ounce. The daily ration of the Italian soldier is—meat 7 to 11 ounces, bread, flour or biscuit 32½ ounces, bacon 9½ ounces, rice 5¼ ounces, sugar ¾ ounce, coffee ½ ounce, wine 8¾ ounces.

If the soldier of the United States is not the best fed soldier of the world, at least, he is the most expensively fed, and has more food and choice of food than the soldiers of any other country. The component articles and quantities of the field ration taken from "Dietotherapy" of the United States soldier is as follows: Beef, fresh when procurable locally, 20 ounces, flour 18 ounces, baking powder, when ovens are not available, 0.64 ounce, yeast, dried or compressed when ovens are available, 0.04 ounce, beans 24 ounces, potatoes, when procurable locally, 16 ounces, jam 1.4 ounces, coffee, roasted or ground, 1.12 ounces, sugar 3.2 ounces, milk, evaporated, unsweetened, 0.5 ounces, vinegar 0.16 gill, salt 0.64 ounce, pepper, black, 0.04 ounce.

Substitute Articles and Quantities.—Mutton, fresh when procurable locally, 20 ounces, canned meat 16 ounces, bacon 12 ounces, hash, corned beef, 16 ounces, soft bread 18 ounces, hard bread 16 ounces, rice 1.6 ounces, potatoes, canned, 12 ounces, onions, when procurably locally, in lieu of an equal quantity of potatoes, but not exceeding 20 per cent of total issue. Tomatoes canned in lieu of an equal quantity of potatoes, but not exceeding 20 per cent of total issue. Tea, black or green, 0.32 ounces, pickles, cucumber, in lieu of an equal quantity of vinegar, but not exceeding 50 per cent of total issue.

The haversack ration is made up of—Bacon 12 ounces, hard bread 16 ounces, coffee roasted or ground 1.12 ounces, sugar 2.4 ounces, salt 0.16 ounce, pepper, black, 0.02 ounce. The haversack ration is issued to troops in the field when beyond the advance supply depots. It contains about 218 grams of fat, 489 of carbohydrates, and 113 of proteins, with a total fuel value of 4,448 calories. It may be mentioned, that in the field and in the absence of fresh meat, bacon is an almost indispensable component part of the ration. It keeps well, is transported easily, when properly cooked is readily digested, and furnishes an ample supply of energy for severe muscular work.

The travel ration consists of—Soft bread 18 ounces, tomatoes, canned, 8 ounces, beef, canned, 12 ounces, beans baked 4 ounces, jam 1.4 ounces, coffee roasted and ground 1.12 ounces, sugar 2.4 ounces, milk, evaporated, unsweetened, 0.5 ounce. The fuel value of this ration is about 2,735 calories.

The Filipino ration includes—Beef, fresh, 12 ounces, flour 8 ounces, baking powder, when in field and ovens are not available, 20 ounces, rice 20 ounces, potatoes 8 ounces, coffee roasted and ground 1 ounce, sugar 2 ounces, vinegar 0.08 gill, salt 0.64 ounce, pepper, black, 0.02 ounce.

Substitute Articles and Quantities.—Bacon 16 ounces, canned meat 8 ounces, fish, canned, 12 ounces, hard bread 8 ounces, onions 8 ounces. The component parts of the ration yield a maximum fuel value of 3,980 calories.

Like all Asiatic eastern races the staple of diet with the Filipino is rice. To avoid beri-beri, the army regulations proscribe that only unpolished rice be issued to them, and that no more than 16 ounces a day be used. The question of beri-beri and the vitamine content of food will be considered later. It may, however, be pointed out that it appears that in the rationing of the United States troops in the tropics, be they white or colored, the advice of Woodruff has been followed, that plenty of meat should be given. The Filipino soldier is required to use the entire meat allowance. The theory that the white man should imitate the natives of tropical climates as regards diet, has been exploded. Moreover, it must be borne in mind that the inability to procure meat and religious scruples are the main deterrents of flesh consumption in Asia. Attention may be further drawn to the fact that the natives who eat meat are finer and stronger specimens of humanity than those who are vegetarians. Munson appears to agree, in the main, with Woodruff, for he says that the present United States army ration is made up of admirably selected articles in more than sufficient variety. He, therefore, is of the opinion that it is not only wholly unnecessary, but quite inadvisable to consider in this connection any nutritive substances outside those articles legally established as components of food for the United States soldier. Munson has suggested the following tables for tropical dietaries: Fresh beef 10 ounces, calorie value 590. Flour 10 ounces, calorie value 1,850. Beans 2.4 ounces, calorie value 240. Potatoes 16 ounces, calorie value 380. Dried fruit 3 ounces, calorie value 220, sugar 3.5 ounces, calorie value 397. Total calorie value 3,677.

This is another table suggested by Munson, as especially applicable to tropical field service, in which the fatty constituents attain their maximum, and the potential energy is high. Bacon 6 ounces, calorie value 1,042. Hard bread 18 ounces, calorie value 1,926. Beans 2.4 ounces, calorie value 240. Dried fruit 3 ounces, calorie value 220. Sugar 3.5 ounces, calorie value 397. Total calorie value 3,825. In the present war the United States troops have not been called upon to fight in tropical coun-

*From *American Medicine*.

tries, nor does it seem likely that their services will be required in any portion of the tropical zone. However, there is a garrison in the Philippines, and British troops, both white and colored are campaigning in perhaps the hottest and most bare region of the world, so that the matter of tropical dietaries for soldiers is of considerably more than academic interest. Experiments carried out recently at the Lister Institute by Harriette Chick and Margaret Hume, and elsewhere, have shown that the embryo of the grain cereals is much richer in anti-beri-beri vitamines even than the cortex; modern processes of milling therefore, left a deficiency to be made from other sources. The most concentrated depositaries of anti-beri-beri vitamines were unmilled cereals, pulses, in which apparently the vitamines were uniformly distributed and not limited largely to the germ, as in cereals and eggs. Meat and vegetables contained a moderate amount, but not in concentrated form, while the pulpy parts of fruit contain little. They were present in milk in small but sufficient quantity. The keeping power of anti-beri-beri vitamines was good, and they stood cooking at 100° C. At higher temperature they were destroyed, and therefore canned foodstuffs which had undergone a process of superheating were deficient. The anti-scorbutic vitamines were much more delicate and elusive.

They disappeared rapidly in the higher temperatures of cooking and sterilization, and diminished even in the pasteurization of milk at temperature below the boiling point.

An interesting object lesson was given on the study of the conditions of British troops during the siege of Kut.

In the early stage, beri-beri occurred among the British troops, but disappeared. During the first two months they received a ration of horse meat. On the other hand the Indian soldiers were supplied with cereals and beans containing abundance of anti-beri-beri vitamines; these had no anti-scorbutic properties, and as they did not eat meat, and fresh fruit and vegetables were not procurable, scurvy was very prevalent among them. This deduction was therefore drawn. For the prevention of beri-beri it is in the highest degree desirable that the germ and the bran of wheat should not be excluded from the flour destined for manufacture of bread and biscuit for troops in active service. This is the more necessary when the troops are separated from fresh food supplies and the rest of the ration consists largely of canned foods, seeing that these articles are deficient in all vitamines owing to their previous sterilization at high temperatures. To prevent scurvy, if a supply of fresh fruit or vegetables is not procurable, germinating pulses should be added to the diet. Although the above may seem somewhat of a digression, yet if looked into closely, it will be observed that it bears not only on soldier rations in tropical countries, but at the present time on the rations in France. Fresh meat is becoming very scarce in Europe and is not very plentiful here. It is much easier to transport canned meat, "bully meat" than refrigerated meat or live animals, the consequence being that canned meat is very largely used by the American and British armies on the Western front. As time goes on more dependence will be placed on canned meat than ever, and it appears reasonable that seeing that these foodstuffs are deficient in vitamines that the deficiency will have to be made up by other foods, and if fresh fruits and vegetables are not procurable, by germinating pulses, whole meal bread, and so on. The calorie value of the field ration of the United States army is high and well balanced but the food supply of the American army as well as the other Allied armies depends on many fluctuating circumstances such as the sources of supply, mainly this country, Canada and to a less extent South America. If the food supply on this side is not very large and if efforts are not made voluntarily or measures enforced to avoid waste, there will not be the food material necessary to feed the soldiers to send to Europe. Again the means of transport present a very difficult problem. In any event it is probable that preserved foods will be employed more and more and it may also happen that the meat ration of the American and British soldiers will be reduced. Thus far the army rations of the Allied powers have been kept up in conformity with the tastes and habits of the several races engaged and in accordance with scientific physiologic requirements.

The Latin soldiers eat less meat and more bread and procure their quota of protein more from the vegetable than the animal world and perhaps thrive as well as the flesh eating English speaking troops. It is impossible to lay down a hard and fast rule for feeding soldiers drawn from various nationalities. Habit, climate and the personal equation all count. What is one man's meat is another man's poison although it is quite extraordinary how man can adapt himself to environment and conditions. Emphasis may be laid upon one point that preserved and dried foods are largely used and in future will be used even more largely. In this connection it will not be out of place to refer to dried milk, a preparation which possesses many advantages for army use. Liquid milk is clumsy to handle in bulk and inconvenient for transport. In the case of dried milk practically all the solids are retained. Hence the labor and cost of transporting the water which represents about five-sevenths of the total weight of fresh milk are avoided. Its keeping properties are unlimited and it is stated that when the desiccation is properly done the nutritive properties of the milk are unimpaired nor are its vitamines destroyed. If all that is claimed for it is true it would certainly seem that dried milk is particularly well adapted for use in armies.

As for the value of alcohol at the front opinions of members of the medical profession are widely divided. Reference has been made to the rum ration of the British army and it has also been pointed out that the Austrian and German armies under certain conditions were given a spirit allowance. British army medical authorities or at any rate the majority of them believe in the efficacy of a spirit ration when needed. French authorities share the British views as to the value of adding a spirit ration to the dietary of men at the front. Its issue is permitted whenever the official in charge of the unit concerned considers it desirable, the spirit usually given being Jamaica rum. On the other hand the use of spirits in barracks or the billets of reserve troops is strictly forbidden and efforts to lessen the consumption of alcohol by giving men an abundance of confectionery and sweets are encouraged. There is absolute agreement among medical men with regard to the value of hot drinks as well—sugared tea or coffee and pea soup. They not only have a calorie value as food but warm the body by the heat of the fluid they contain.

Hot food is of immense assistance to those who have to undergo extreme and prolonged exposure to inclement weather and the rum ration might be replaced with advantage to all concerned by hot sugared tea or coffee. The medicinal employment of alcohol may be indicated in the trenches in the case of exhausted soldiers, but as a routine practice its obvious drawbacks more than counterbalance its possible advantages. It may be stated that the general view of those competent to speak with authority is that it is best in the interests of health and the fighting ability of the soldiers not to allow spirits as a component part of the soldier's ration. With regard to beer or wine, perhaps to those who have been accustomed to their use, moderate amounts may exercise no prejudicial effects. However, there is no doubt that alcoholic drinks should not be permitted to those engaged in aviation work or in the manipulation and firing of big guns. It was mentioned in the early part of this paper that the slogan, "Food Will Win the War" is correct. Furthermore, the soldier who is the best nourished will fight the best, and therefore the energies of all in this country should be concentrated upon supplying our own soldiers and those of our Allies with abundance of food.

It is hard to definitely state the comparative value of army rations, owing to the different habits of the various races engaged in the present war. Yet this much may be said that regarded from a comparative standpoint the American army so far as rationing is concerned need fear no comparison.

A Jungle Incubator

By Lee S. Crandall

Among the rhododendrons near the Jungle Walk in the Zoological Park, there is a heap of leaves and forest debris. It appears commonplace and uninteresting, but its origin and purpose are not those of the conventional rubbish pile.

The fauna of Australia contains many curious forms. Its marsupial mammals, paralleling in a marvelous way numerous groups of more highly organized creatures, are well represented in the collections of the Zoological Society. Its birds, while less generally remarkable, still include many species of unusual habits. Two groups in particular, one containing the emus and cassowaries, the other the megapodes or mound builders, have developed aberrant methods of reproduction. The emu family, with its prettily striped babies, motherly father and advanced mother, are well known to our visitors. But now we shall make the acquaintance of an ultra-modern bird, whose habits might inspire the imaginative humorist. Here the tendency to slough off maternal duties has reached its logical end, for nobody cares for the babies at all!

The Encyclopedia Brittanica says that artificial incubation has been known to the Egyptians and Chinese from "time immemorial." That honored phrase is not chronologically exact, but whatever the period may be, it is fairly safe to say that incubators were in use before the days of Confucius, and without the guiding intellect of man. In the untravelled bush of Australia, birds were making use of the principle on which the modern 10,000-egg machine is founded.

The brush turkey, the most familiar bird of the megapode group, nests from September to January, a period that, in the Antipodes, corresponds to our spring and summer. But this nest building consists of no conventional weaving and binding. The brush turkey's skill lies rather in its feet than in its beak, and it is well equipped for the work to be done. So generous is its endowment, in fact, that the length of its toes, coupled with the bare and highly colored head and neck, led to its early description as a vulture, although it is really a member of the family of fowls. But these feet were fashioned for a softer purpose than holding prey in process of rending.

Turning its back to the chosen spot, the brush turkey begins to scratch. And then it is obvious that this is indeed his forte. Huge footfuls of leaves and twigs from the jungle floor fly toward the common center as though borne on the wings of an infant whirlwind. Material frequently is brought from considerable distances and often the ground for many feet about is scraped quite clean. Small streams are no obstacle, for the brush turkey dredges as well as he gleans.

In an incredibly short time, a heap of very respectable proportions has been formed, perhaps as high as six feet and ten or twelve in diameter. The core is composed of humus and leaves in an advanced stage of decomposition. The outer layer of coarser material forms a protective jacket for what is destined to become the incubation chamber. After the mound has stood for a period sufficient to insure the beginning of fermentation, the cover is scraped away and a hole is dug in the center of the central mass. Here the female deposits her egg, point down, and the mound is again closed. It is commonly stated that the work of building the mound and preparing it for the reception of the eggs is performed by the male alone. Further observations seem necessary to confirm this belief.

A period of several days appears to intervene between the laying of each egg and its successor, so that a mound operating at full capacity contains eggs in all stages of incubation. Each pile is usually the property of a single pair of birds, but huge structures, measuring many feet in diameter, have been found. These large affairs are said to be used in common by several pairs of brush turkeys—somewhat after the fashion of the municipal plants which we are sometimes told will be the final outcome of modern human tendencies!

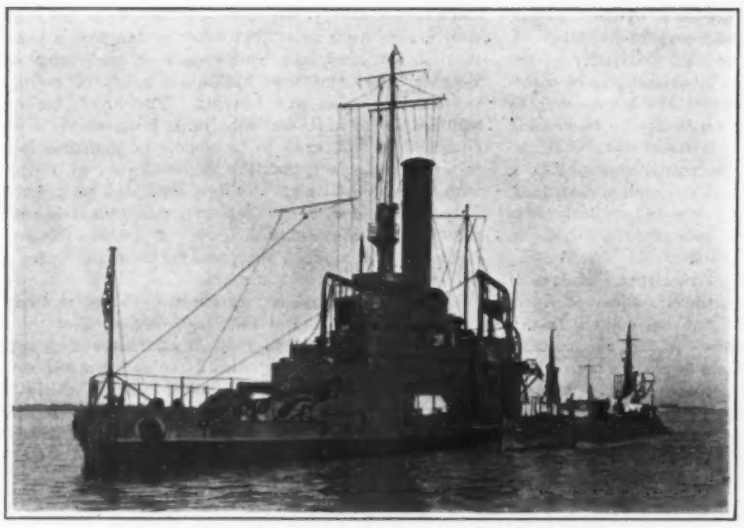
While the mound contains eggs, it is watched over with great solicitude by the parents, which are quick to repair any damage. The heat generated by the decaying vegetation gives the interior of the mound a temperature of about 95° Fahrenheit. From 100° to 103° are required for the incubation of the eggs of the common fowl, but less heat seems to be needed for these of the brush turkey. After a period of six weeks, the first chick emerges. Buried beneath a heap of sodden rubbish, his case seems hopeless. But youthful as he is, the spirit of the upward trend has marked him for its own. From his parents he has inherited sturdy feet and the will to use them. He promptly scratches his way to the surface and begins to preen his feathers in the pleasant sunshine. For feathers he has, and wings as well.

Disdainful of parental discipline, as might be expected he scuttles off into the underbrush, to search for the insects which will form his first meal. But the parents are not offended, for to them he is a perfect stranger. When night approaches, this infant prodigy flies with his precocious wings to a convenient perch, and spends the night in happy indifference to his lonely state.

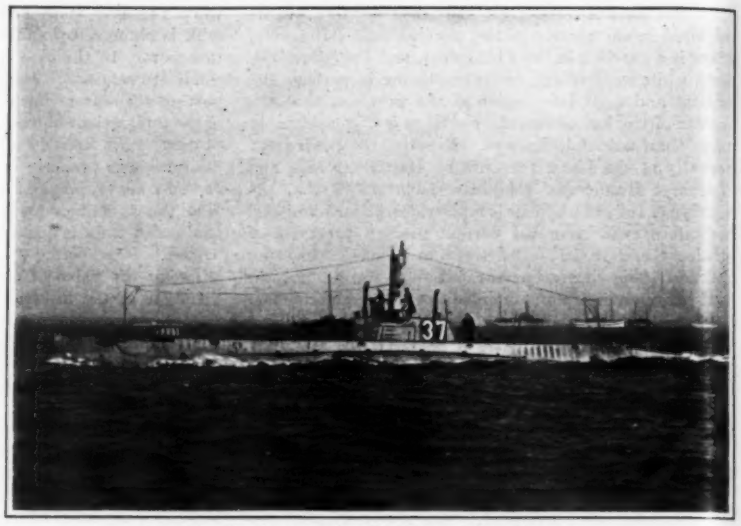
And now what shall we say of our own "upward trends" and "advanced movements"? For this dingy bird of Australia has developed the problem of parental duties to a state which even our ultra-thinkers have hardly dared approach.

In the summer of 1917, two brush turkeys arrived at the Zoological Park. In the belief that they were a pair, the birds were placed in a large run at the Ostrich House. It soon became apparent, however, that both were males. It is not the nature of the brush turkey that two males should occupy the same enclosure, however large. This point was brought so strongly to the attention of the weaker bird that it took leave, climbing the eight-foot fence and launching itself in lop-sided flight from the topmost strand. A thorough search failed to reveal its whereabouts and we had given up hope of finding it, when a strange accumulation of leaves and sticks was reported near the Jungle Walk. Investigation showed the ground nearby to have been cleaned in a workmanlike manner. Mystified at first, and suspecting an overindustrious child, we found that our lost brush turkey was obeying the commands of instinct. He must build a mound, although its purpose could not be fulfilled.

After a winter passed in the Pheasant Aviary the bird was liberated this spring and promptly returned to his haunts in the Beaver Valley.—*Bulletin* of the New York Zoological Society.



Mother-boat for submarines equipped with wireless



A submarine boat equipped with portable wireless

Radiotelegraphy

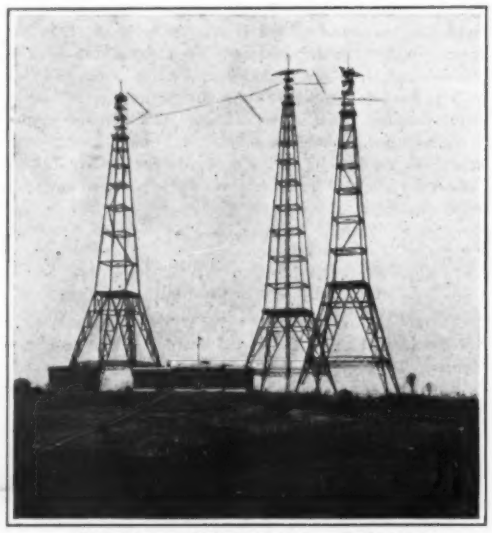
Its Uses and Possibilities in the War

By Guy E. Mitchell

AMONG military experts the opinion is steadily growing that the great world conflict will be decided in the air, and that one of the most important factors in that decision will be radiotelegraphy, the science of the utilization of Hertzian waves for telegraphing without wires, commonly known as the "wireless." Safe conduct across the seas of the vital necessities of war—men, munitions and food—depends in large measure upon the effectiveness of wireless communication which must cope not only with the natural perils of ocean travel but also with the murderous thugs of the undersea, the German and Austrian submarines and mines.

Investigations and discoveries in the field of radio communication have extended over a period of nearly a century but it was not until a few years ago that wireless telegraphy became practicable and was made the subject of Federal regulation. Perhaps no legislation has contributed more to the common good than the statute which requires that all steamers leaving a port of the United States carrying fifty or more passengers shall be equipped with an efficient apparatus for radio communication capable of transmitting and receiving messages over a distance of at least one hundred miles, day or night. But one exception to this requirement of law has been made and that is in the case of steamers plying between ports or places less than two hundred miles apart. Owners of vessels so engaged seldom, however, avail themselves of this exception, being farvisioned enough to anticipate returns, by way of salvage and commercial service, far and above the cost of installing and maintaining the apparatus.

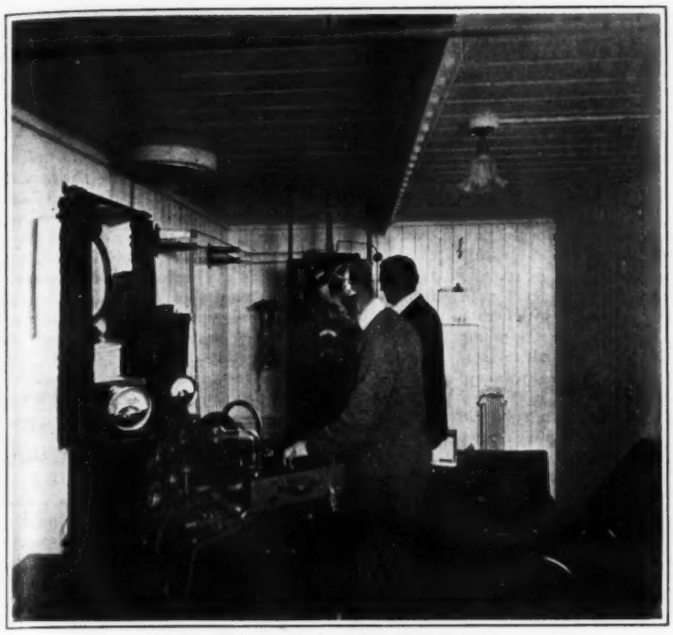
As might naturally be supposed in a rapidly advancing science, accomplishments in the field of wireless communication have greatly exceeded the minimum distance requirement of law. The effectiveness of radio depends primarily upon atmospheric conditions, the clear, cold weather of winter being more favorable than any other to higher accomplishment. "Freak" messages, so called, have been "picked up" at almost unbelievable distances, sometimes exceeding four thousand miles. It will be recalled that just prior to the date of America's break with Germany reports were numerous that highly confidential messages were exchanged between the Tuckerton, N. J., wireless station and the once famous radio plant at Nauen, Germany, not far from Potsdam. Signals issued from steamers on the Atlantic coast have been heard on the shores of England—a distance of approximately three thousand miles—but confirmation of this is not to be had from the official records. Recent experiments have, however, produced scientific data to a distance of over one thousand miles, and it is probable that these results have lately been exceeded. The particular record was made in tests between two United States cruisers and the large Fessenden station at Brant Rock, situated directly on the shore twenty miles south of Boston. The apparatus used at the station consisted of a steel tower 420 feet high and three feet in diameter, thoroughly insulated at its base. Four arms, 50 feet in length, were extended from the top of the tower, and from each of these two 300-foot cylindrical cages were drawn out by means of guys at an angle of about 45 degrees. This formed a system of eight conductors spaced cylindrically about the tower. The cages were approximately four feet in diameter and consisted of four wires each, separated by a system of hoops. These cages were insulated at the bottom and electrically connected to the steel tower at its top, thus forming a type of umbrella antenna. The motor generators were 500-cycle machines rated at 100 kilowatts, producing 1,000 sparks per second. These and other equally successful experiments are important contributions both to humanity's cause and to science and serve to advance radiotelegraphy to the front rank of agencies employed in safeguarding lives and property at sea. With these remarkable performances cited, the dangers which confront our troop transports and merchant ships become less acute, especially when supported by official records which reveal instances of marvelous rescues, both heroic and spectacular, effected solely through the use of radio. The wreck of the White Star liner "Titanic," still vividly remembered as one of the most appalling



U. S. Navy wireless towers at Radio, Va.

marine disasters in all time, furnishes a striking illustration. Even its gruesome details do not obscure the record of 703 lives saved by other vessels which responded to the wireless distress signals. The "Lusitania," wantonly torpedoed by a German submarine ten miles off Kinsale, Ireland, also offers mute testimony to the efficiency of this benevolent science. Though clouded with the details of Prussian frightfulness, the story of her destruction records the fact that the SOS signals saved some 754 persons from horrible death by drowning. These are the two late conspicuous examples of wireless effectiveness at sea, but there are numerous other instances, proof of which is to be found in official records, wherein radiotelegraphy has flashed its messages across the seas and brought relief to thousands of persons and enormously valuable property, apparently hopeless lost. The steamship "La Touraine," bound from New York to Havre with an inflammable cargo, was discovered on fire 400 miles west of the Irsh coast. Four steamships answered the SOS calls, and while the fire was finally gotten under control by the crew, one of the ships remained nearby ready to take off the passengers in case this should be necessary. This same vessel convoyed the "La Touraine" as far as Prawle Point, and two French cruisers escorted the injured steamer to Cherbourg. Again, when the steamships "Munroe" and "Nantucket" collided, wireless saved the day by bringing others ships to the relief of the 85 persons who would certainly otherwise have lost their lives. This accident was accompanied by a singularly pathetic incident. The wireless operator on one of the ships—the man whose heroism brought assistance—gave his life belt to a woman passenger and himself made the supreme sacrifice. This recalls the more recent case of the operator on the Army transport "Antilles," another victim of Germany's hellish creed, who a few months ago preferred to go down with his ship rather than save himself when there were warning signals to be given. A few years ago the steamship "Camino," sailing from Portland, Ore., ran into an 80-mile gale. Heavy seas swept the decks and the terrified passengers gathered in the saloon weeping and praying. The gale raged all night and at 5.30 in the morning the propeller dropped from the broken shaft to the bottom of the sea. The vessel was 15 miles off shore with the wind each moment carrying her farther to sea, but persistent calls finally brought the steamship "Watson," which rendered signal aid to the disabled vessel. When the Holland-American liner "Ryndam" collided with the fruit steamer "Jos. J. Cuneo" south of Nantucket shoals, four United States battleships answered the distress calls, one of them taking aboard the 230 passengers of the "Ryndam" who had been transferred to the "Cuneo." Not a single life was lost in what would undoubtedly have otherwise been a shocking marine disaster. November, 1913, was noteworthy for terrific storms on the Great Lakes. It is a matter of record that 19 vessels, none of which was equipped with wireless, were destroyed during that month and that all vessels having radio apparatus received warning of approaching storms and were able to make havens of safety. Weather forecasts are regularly sent to sea at certain times, varying with the locality. These reports are made through cooperation with the local offices of the United States Weather Bureau, coast stations being prepared to give local forecasts to passing vessels without charge.

As efficient as the operation of radio, is the administration of the law. Competent radio engineers and inspectors, located in the largest ports of entry on the Atlantic and Pacific Coasts and on the Great Lakes, insist upon a rigid enforcement of the statute and rules. Transmitting stations are zealoulsy inspected and radio operators searchingly examined to determine whether the requirements are fully met. Land radio stations exist in classifications ranging from the lowest restricted amateur to the highest public service station. Each of these stations and vessels has a separate radio call, assigned in accordance with the service regulations of the International Radiotelegraphic Conventions. Under these regulations the call letters of the stations in the international system must each be formed of a group of



Inspecting a wireless plant for a license

Regulation receiving room on a merchantman

three letters easily distinguishable from one another. These call letters were distributed among the nations which signed the conventions, and these in turn disseminated information on the subject for the guidance of operators both on ship and on shore. Great Britain, for example, was assigned all combinations beginning with the letters B, G, M, Y and Z and all combinations from VYA to VZZ. France received all combinations beginning with the letter F and all combinations from UAA to UMZ. Italy had all beginning with the letter I, Japan all beginning with the letter J, and the martyred Belgium all combinations from ONA to OTZ. Among the enemy countries which signed the conventions, Germany received all combinations beginning with the letters A and D and all combinations from KAA to KOZ and from TNA to TZZ; and Austria-Hungary was given all combinations from HAA to HFZ, from OGA to OMZ, and from UNA to UZZ. The United States was assigned all combinations beginning with the letter N and all beginning with the letter W and all combinations from KDA to KZZ, inclusive. It is to be assumed, however, that none of the nations at war is using the calls which were assigned them by the conventions. The United States had about two thousand call letters which were reserved for government stations and stations open to public and limited commercial service. All combinations beginning with the letter N were reserved for government stations, and in addition the combinations from WUA to WYZ and WXA to WZZ were reserved for Army stations. The combinations KDA to KZZ, with a few exceptions, were reserved for ship stations on the Atlantic Coast and the Gulf of Mexico and for land stations on the Pacific Coast. The combinations beginning with W (except WUA to WYZ and WXA to WZZ, as already explained) were reserved, with few exceptions, for ship stations on the Pacific Coast and the Great Lakes and for land stations on the Atlantic and Gulf Coasts and the Great Lakes region. These call signals immediately identified the sending ship or station, NAD, NAH, and NAI signifying the naval stations at Boston, New York, and Philadelphia, respectively; WUP and WUQ the two United States Army stations at Washington, D. C.; WJX the Marconi station at Jacksonville, Fla.; KPE the harbor department station of the city of Seattle; and KFS the Federal Telegraph Company's station at San Francisco, Cal. Similar combinations identified the ship radio stations. The battleship "Alabama" was assigned the letters NBI, the "Texas" NCD; the steamship "Arapahoe" of the Clyde Line used the letters KVB; the Standard Oil steamer "Llama" the letters KSI; the Mallory Steamship Company's steamer "Neches" the letters KEE, and so on through the long list of assignments. Radio inspectors awarded the call letters for the thousands of amateur stations in the United States but, as all such stations have been discontinued for the period of the war, these assignments are of but passing interest.

Radio operators are licensed under classifications which range from the amateur, second grade, to the top-notch operator known as commercial extra first grade. Candidates for the highest class must be able to receive at least 20 words a minute and have a practical knowledge of the theory, care and operation of a commercial ship outfit. A second-grade license requires a speed of not less than twelve words a minute and the possession of slightly less theoretical knowledge. For the period of the war, however, emergency licenses are granted on the receiving tests alone, theory being omitted altogether.

Progress in the field has been so rapid and results so encouraging that experimenters have lately turned their attention to the utilization of wireless in other lines of military or naval development. A most important

Examination of radio operators at inspector's office

achievement of the army air service is the operation of wireless on contact patrol machines at the front. These are the airplanes which follow advancing or retreating bodies of troops and note whether they are performing according to carefully planned battle schedules. Equipped with wireless for communication with headquarters of troop detachments, the value of this service, whether in large or small maneuvers, can not be measured by mathematical standards. It has also been demonstrated that wireless may be used in detecting the presence of submarines, whether submerged or not, over ranges of two miles or more, depending upon the wave length used. The discovery was made, quite accidentally, a few months ago in connection with a series of experiments with an undamped Audion receiving set. It was observed that when the Audion receptor was suitably tuned so as to produce radio frequency oscillations, at certain times a peculiar sound effect could be noticed in the telephone receivers connected to the circuit. This change in the circuit, manifested by the unusual sound in the telephone receivers, remained a mystery for some time, but careful observation finally developed the fact that this was due to the effect of a passing railroad train at a distance of about a quarter of a mile. Inasmuch as the railroad tracks did not approach the building in which the wireless receptor was located, it was decided that the capacity effect of the steel railroad train on the wave radiated by the antenna changed this wave in such manner as to be easily noted in the translating apparatus, namely, the telephone receivers in this case. Applied to the problem of locating submarines or torpedoes (for the apparatus is used effectively on any metallic body) it was readily shown that the U-boat, whether submerged or not, caused a reaction on the radiated wave from an antenna located either on ship or on shore. The experiment has been successfully conducted over considerable distances and not only the metallic body itself but the direction in which it lies may now be definitely determined. Underseas monsters lurking in the dark lanes of ocean travel will frequently be caught in their lair by this latest agent of civilization.

The fortifications board has manifested a keen interest in the Hammond system of radio control of torpedoes and of aeroplane control of such torpedoes, two inventions which it is said may revolutionize naval warfare. Money is available for the purchase of the radio-control rights, and it is expected that some important announcement will soon be forthcoming in this connection. The value of developments in these lines is well recognized in the plans for home defense, world-renowned authorities having expressed their opinion that a German air raid on the American coast is not a remote possibility. It will be seen, then, that radio may yet be the means of saving some of our principal seacoast cities from the fate of certain historical centers in Europe which have been victimized by the mailed fist.

That there is an imperative need for radio operators, particularly in the Navy and Signal Corps, goes without saying. Had it not been for the amateurs of the country the radio departments of the United States service would have been greatly handicapped. It is a matter of great pride, however, that the appeals of government have met with the same patriotic responses that have characterized volunteers in other lines of service to the country and that numerous public and private schools have been established and are daily sending forth competent operators to meet the exigencies of war. Notable among the private institutions are the Marconi Institute, New York, the National Radio School, Washington, D. C., and the Eastern Radio Institute at Boston. Thirty-seven colleges in the United States are also running special courses for radio instruction, principally

under government supervision. At Harvard University 4,000 students are now being trained by the Navy in a course extending over a period of 16 weeks. Entrance requirements are that the student shall be able to receive consecutive matter of mixed letters and figures at a speed of ten words per minute and shall have a working knowledge of radiotelegraphy. Other Navy schools are maintained at the different navy yards, as, for example, at Brooklyn, League Island, Norfolk, and Mare Island, and at the Great Lakes training station. The Signal Corps of the Army also maintains large training camps for radio men, and at the Maryland Agricultureal College and the Carnegie Institute of Technology special courses are offered under direction of this same arm of the service.

Consideration of this subject of radiotelegraphy as a factor in the prosecution of the war can not be had without realization of the importance of expanding this means of communication in the struggle for commercial supremacy which will follow the cessation of European hostilities. Radio will link this country with all the important markets of the world and will undoubtedly contribute as much as any other agency in elevating the United States to the highest position in the list of international competitors.

Game Farming for Pleasure or Profit*

By Herbert K. Job
Of the National Association of Audubon Societies

DURING the last few years a remarkable tide of interest in the subject of game farming has arisen all over the country. Just previous to this was a period of experimentation, and of skepticism on the part of many as to the practicability of the work—comparable to a similar period in the history of aviation. Now that successful demonstration has been made by many persons, game-farming enterprises are starting up all over the United States and Canada. While efforts with some species of game are still in the experimental stage, enough success has been attained with various important species to make propagation of game clearly worth while.

Aside from any financial profit, there is a distinct fascination which leads many to undertake such work. There is a widespread interest in wild birds, an enjoyment of their very presence, especially of kinds of any considerable size or which have become scarce. The hunting instinct, of pursuit and acquisition, is also very keen in many people. Actually to be able to produce charming wild bird life, especially such as is connected by association with exhilarating sports afield, to watch the birds grow up, to have them thus readily accessible in the open, with superior opportunity to study and observe wild traits, are most enjoyable.

The propagation of wild game is destined, furthermore, to become one of the most important factors in saving and restoring valuable species which the growth of "civilization" inevitably would render extinct. It is most important that legislation should encourage and promote the propagation of game, not obstruct it. We are just emerging from a period when progress clearly has been retarded by well-meant but short-sighted efforts to save it. A hunter pays a dollar for a license and kills, say, a hundred birds. It has been lawful to have many dead ones, but a crime to be caught with *one* alive and unwounded! Our domestic poultry was originally a wild species—very wild—with restricted range. Thanks to "game farming" it is now the most abundant and useful species on earth. Had it been "protected" as we have been protecting our game, there probably would not be one left on earth today. European countries are far ahead of us in these matters. It is estimated, for instance, that the pheasant population of England is double that of the human, the result of just a few decades of broad-minded legislation, allowing people to hold, breed, and sell game that they had raised. Happily, we are emerging rapidly as a nation from our recent darkness, and state after state is passing more liberal laws.

The propagation of wild game requires careful attention to details especially to matters of sanitation as wild species are very susceptible to diseases of uncleanliness. No one is qualified to undertake it who has not a deep interest in the birds themselves. Always begin on a small scale and learn the technique by first-hand experience. It would be the height of folly to lay out plans on paper and plunge into any great game-farm project. Game farming had better begin as an adjunct to other diversified farming and make a gradual and healthy increase.

In making a beginning it is usual to start with a few ring-necked pheasants for a "try-out." These are easily obtained, are hardy, less liable to disease than some and every dealer can furnish booklets showing how to proceed. Further pheasant raising is considered the most lucrative branch of game breeding at present, even though many are going into it. The birds are light eaters, of good size, very prolific, and both birds and eggs bring excellent prices, with wide demand for them. The common ring-necked pheasant is the best all-round species for market and for stocking game preserves. Many other kinds are reared also, more particularly for ornamental purposes, being rather less hardy, but bringing fancy prices. Of these the best known are the golden, silver, Manchurian, Reeves', and Lady Amherst's pheasants. Beginners had better learn with ring necks before trying these.

The breeding and rearing of quails of several kinds, now has been made entirely practicable, although the commercial side has not been thoroughly worked out. Young quails are delightful to handle, and the actual rearing of them on a small scale is considered by some to be more easily accomplished than the rearing of even pheasants, as they stay with the hen and run with her for shelter to the coop during showers, whereas the young pheasants often merely squat in the grass, and, further, the quails stay better in one locality when grown up. The stock in confinement, however, cannot be crowded as much as pheasants without danger from epidemic diseases. Also finer wire, which at present is very costly, is required for quail pens.

To raise pheasants, we may begin in either of two ways. We may buy eggs from a game farm and set them under hens, or we may buy, in late fall or early winter, adult breeding stock, usually one male to four or five females. If the second method is followed, the pheasants, with wings clipped, should be kept in a wire enclosure, sheltered on north and west, and containing simple board and brush shelters under which the birds can take refuge from storms. Outdoor cold does not trouble them when thus cared for. About the middle of March they should be removed to breeding quarters. For these a separate small enclosure should be provided for each breeding unit of a cock and four or five hens. Each of these pens should be about 14 feet square, bottomless and portable, with 2 inch mesh wire, but boarded up two feet from the ground. There should be board shelters from storm, and brush heaps under which nests may be concealed Pheasants are fed mostly on ordinary small grain, such as "scratch feed," and any convenient "green stuff," with a little rich laying mash in spring. In northern districts laying begins about the middle of April.

The young when first hatched must be kept carefully shut in with the hen, or they will escape and get lost. After one day, hen and brood are removed to a fresh coop, fed and confined for another day, then for two days allowed to run out through slats into a very small yard. After this they are allowed to run at will, the hen being shut in the coop when there are a number of other broods, to prevent mixing and fighting of hen mothers. Otherwise the hen could range with them. By this time they know the call of the hen and stay with her. Coops had better be from 50 to 60 feet apart, in a grassy field or pasture. There need be no fence if cats, dogs, and vermin do not attack them. Preliminary trapping of vermin is important. For any considerable game farming, however, it is better to have at least two fields surrounded by wire fences, seven or eight feet high over which animals will not jump and over which the young seldom try to fly until they are well grown when they learn the way back and forth, getting range and natural food outside but returning to the enclosure at feeding time. When fully fledged they can be caught readily in traps and disposed of as desired.

Quails are managed in the same general way as pheasants, with modifications due to the fact that the species is monogamous. The common bobwhite breeds best when separated arbitrarily into pairs, about the first of April, and each pair placed in a small, separate enclosure about 8 by 4 feet in size, with a thick brush heap at each end and a little board shelter for storms. Each hen usually lays from twenty to forty eggs a season, sometimes more. She will seldom incubate her own eggs in captivity, and it is best to rear the young with bantams. The eggs are so small and fragile that large hens would surely crush them. For the first week after the hatching treat the young quails like pheasants, then release the hen and let her roam with the brood, as they are by that time strong enough to follow.

Other kinds of quail which can be raised are the California, Gambel's, scaled or "blue," and mountain species. All but the last are southern forms, but all can stand cold under restraint, certainly when fed and sheltered from storms, and probably, with some care, could be acclimated to conditions of medium severity, as scaled quails from Mexico have been bred and wintered free in northern Connecticut, by United States Senator George P. McLean—although one storm took heavy toll of them. Of the scaled and mountain quails the sexes resemble each other and cannot with certainty be segregated, but fortunately all these four species breed when put together, each kind by itself, in a larger enclosure.

The common partridge or ruffed grouse, which is very hardy and might be supposed to be one of the easiest to breed, is in reality one of the most difficult, owing to peculiar traits, especially the pugnacity of the male. They are raised in confinement in small numbers, but it requires a separate large wire enclosure for each pair, making the cost prohibitive as a business proposition. Experiments, however, are under way, and some solution may yet be found. There are other kinds of grouse yet to be made subjects of careful study, notably the "prairie chickens" of the West. Likewise there is an extensive field with many foreign species of gallinaceous birds.

Our native wild turkey is beginning to be bred successfully under restraint. This undertaking requires a considerable tract of field and woodland enclosed with high wire fencing. Like the domestic variety, the wild form is sensitive to diseases of captivity, and the young have to be managed very carefully. Most of the stock sold as "wild" turkeys are only domestic ones or crosses. The domestic bird has a white or light buffy tip to the tail and the same light edging to the feathers of the rump, whereas these corresponding feathers of the true eastern form are dark rusty brown and reddish brown or maroon respectively.

The breeding of wild waterfowl is a most fascinating pursuit, especially the breeding of wild ducks, and also of some geese and swans. The main requisite is a small pond, preferably marshy. An acre or two is an ideal size, although for fewer birds one much smaller will do. This should be enclosed with a wire fence 6 or 7 feet high, 1-inch mesh at the bottom for about 3 feet up, the rest ordinary poultry size. An equal area of land should be enclosed with the pond, preferably marsh, swamp, and field, with plenty of rank growth to hide nests. The mallard is by far the easiest to raise, and is produced on game farms in great numbers. Through long breeding in captivity it has become very prolific, and in this respect it is in a class by itself. The tendency of long confinement is to increase the size of the bird and lessen the power of flight, and in buying stock one must be on his guard, if he desires to have true wild ducks and not domestic fowl.

The wood duck, our most beautiful wild native waterfowl, is a charming species to breed. Although not prolific like the mallard, it will breed every year, and produce two layings if properly managed. As with other wild ducks in captivity, to hold them in open enclosures for breeding the stock should be pinioned. This species in the wild state nests in hollow trees, but in captivity uses nesting-boxes on posts, with a cleated board walk leading up to the 5-inch hole in the side. Small nail kegs answer very well, or any ordinary box. The posts are set out in shallow water preferably, or else on shore amid shelter of shrubbery. When the laying is complete, the eggs should be taken at once and hatched under a common hen, one of fairly light weight being best. The duck will probably lay another set, which she may be allowed to hatch and raise, provided the pond is free from large fish, frogs, turtles, or snakes, and there are not many other ducks. Wood ducks are in great demand as breeding stock, and bring from $10 to $20 a pair, so that their propagation is quite profitable. Until recent years most of the stock used in this country was raised in Holland.

Wild ducks' eggs also hatch quite well in incubators, if given all possible moisture, and the young can be raised in brooders, although it is easier and less exacting work to employ hens. In the latter case the hens are kept shut in the coop, and the young allowed to run in and out through slats, confining them to a wired yard on grass, and moving them to a new spot now and then. The coop should be kept very clean and fresh sand frequently spread over the bottom.

Of course there are many other kinds of wild ducks, but the work of breeding them in this country, especially our native kinds, is still in its infancy. The main hindrance is that wild captured ducks are loath to produce eggs at first. If kept in a suitable pond where they are not disturbed, and where there is plenty of cover, although they do not lay the first year, they probably will begin the second season, and do still better the third. The young should be reared by hens, and will be tamer and more ready to breed than their parents. This is the way to build up breeding stocks and solve this problem with various native species hitherto largely untried. Such hand-reared stocks will prove very valuable, and already are in great demand at special prices. Those who produce them first will obtain the greater rewards.

Geese and swans raise their own young. The various species are hardy and mostly take care of themselves, except that one must feed them a little grain. They are very pugnacious during breeding time, and each pair must have a considerable area entirely to itself. The common native wild Canada goose breeds readily in captivity, but thus far there have been very few instances of other species of American wild geese breeding in captivity. The same is true of our wild swans. There is here a large field for experimental research.

*Journal of the Am. Museum of Natural History.

Practical propagation of upland game birds and wild waterfowl by the public is now an accomplished fact, and is one of the most fascinating modern developments of popular study of wild birds. It is a real delight to see one's own broods of pheasants or quails feeding on the lawn or in the pasture, or one's own wild ducks swimming trustfully to their protector on the pond shore asking for food—the same wild game species, it may be, that one has hunted in glorious bygone days afield. I speak from happy experience, as can many others, and I advise lovers of the great outdoors and its wild denizens to try for themselves this new intimate relationship with wild bird life.[1]

The Photography of Insects*

By Geo. Grace, B. Sc.

INSECT photography has the advantage over most of the other branches of natural history photography that it is almost an unexplored field, and the results, even those of a beginner, may easily be of real scientific importance. Indeed, so little has been attempted that there are still many common British insects which have not yet had their life stories recorded by the camera, and any worker may hope to get results both valuable and unique. The pursuit is also an extremely fascinating one; and, just now, has the additional advantage that much of it can be done on one's own private premises, and therefore beyond the reach of military regulations.

Like the insects themselves, the subject is divided, naturally, into three distinct branches, each of which presents its own problems and has its own sphere of usefulness. They are: (1) The photography of living insects in their natural surroundings; (2) the photography of living insects at rest in a well-lighted room or conservatory, when longer exposures are possible; (3) the photography of mounted insects for scientific purposes.

The "snapshotting" of insects in the field is much more difficult than ordinary instantaneous photography. The insects are so small that the camera needs to be very near them, if the image is to be of useful size. The larger insects, such as butterflies, can be taken half or three-quarter full size, and, if necessary, afterward enlarged; but smaller insects, such as flies, bees, and sometimes even caterpillars, need to be taken quite full size, if not larger, in the first instance, or the final results do not show enough of the structure to be of use or interest. In order that we may be able to give a short exposure in these circumstances, even when using extremely rapid plates, a large aperture must be used; and the consequent depth of focus is so small that, if the camera is held in the hand in the ordinary way, it is more than likely that the result will be out of focus oftener than in. After many attempts I have given up trying to make such exposures, and now always rest the camera on a tripod or some other solid support. When this is done, it is not really difficult, especially when using a reflex camera, to get well exposed negatives on sunny days; and even on bright days when the sun is not actually shining there should be no difficulty either.

The procedure I have found most successful is to select a suitable bunch of blossom which is likely to be visited by the insect whose photograph is needed, and to set up the camera and focus it on the flowers. If necessary, a plain background can be arranged, by placing a white or other suitable cloth behind the plant. One has then to remain quiet until the insect comes round. Fortunately, most insects do not resent the presence of strange objects, if there is no motion to alarm them; and will go on with their business, quite unconcernedly, within a few inches of the lens. It is then only a matter of patience to watch the screen until the creature has taken up a suitable position and is in focus, and then to press the button.

All work of this description, however, labors under the disadvantage that the extremely rapid non-orthochromatic plates, which are most suitable as far as rapidity is concerned, are very imperfect in their capacity for rendering colors properly: and in taking insects it is more necessary to obtain a correct representation in monochrome than it is in almost any other branch of photography. Nevertheless it is often possible, in spite of such disadvantages, to get interesting and useful pictures.

But the only way absolutely to conquer the color difficulty is to use color-sensitive plates, and to manage with the longer exposures which they entail, especially when a color screen is used. Unfortunately, this is generally impracticable out of doors, owing to the motion caused by the wind, even when the insect is at rest. To remedy this, I have done a great deal of work in a conservatory; but a well-lighted room with a large window can be made to do nearly as well.

The insects are brought home, alive, in the usual entomologist's boxes, or, often better still, are bred in the place where they are to be photographed. When they have reached the stage at which it is desired to get a photograph, they are transferred to a branch of the food plant, either grown in a plant pot or simply standing in a pot of water. This is placed in a suitable light with a background of paper or tinted cloth, and watched until the insect settles down into a good position. This is more interesting than it sounds, for each insect has its own habits, and these have to be studied carefully before success can be attained. Some caterpillars, for instance, only feed at night, and during the day will rest quietly on twigs or leaves. These are easily dealt with. Others seem to take spells of alternate feeding and sleeping, and it is often necessary to watch several hours until one has satisfied its appetite and is willing to take a nap in a suitable position. Others, again, never seem comfortable in a bright light, and an exposure can only be obtained after the exercise of an infinite amount of patience and tact.

This indoor photography necessitates long exposures, especially as it is advisable to use a yellow screen even with panchromatic plates; and the necessary depth of focus can only be obtained by using a small stop. Consequently the exposures often run to thirty seconds and even longer. Such prolonged exposures, of course, can only be given when the insect is in absolute rest, and are often cut short by sudden movements when it wakes unexpectedly: but experience seems to give one the power of judging how long it will remain still and when it is advisable to begin operations.

The uncertainty of the results, until the plate has been developed, and the pleasure of pitting one's skill and patience against even so humble a creature as a restless caterpillar, have something about them akin to the pleasures of big game hunting, without its enormous expense and other disadvantages.

I never realized until I took up this work how very imperfect is the color rendering of even orthochromatic plates, especially when dealing with the greens and yellows which are so common in nature. It was only after trying quite a large number of experiments that I found that panchromatics would do what I required.

Of the third branch of my subject I need say very little. As a branch of sport it lacks the fascination of either of the other two; but in cases where it is desired to display certain points about an insect which are unobtainable while it is alive, it is necessary to resort to it. A certain degree of entomological knowledge and skill in setting insects are required, in order to make the dead insect take the proper position until a suitable negative has been obtained.

The actual photography of mounted insects presents no difficulties to anyone who can copy. All that is necessary is to remember that a diffused light, even if not very strong, gives much better results than a strong light from one direction. With this diffused light, and an arrangement of white screens to neutralize the shadows, and, of course, with panchromatic backed plates, the results should be good from the very first exposure. But, although pictures extremely valuable scientifically may be thus obtained, I have never felt that post-mortem photography is so interesting as that described earlier in this article.

[1] Realizing that "game farming" is proving one of the very best means of interesting the public in wild bird life, its conservation and increase, the National Association of Audubon Societies more than three years ago founded its "Department of Applied Ornithology," in charge of the writer, the purpose of which is to interest and instruct the public in practical measures to increase wild bird life. These measures include attracting, feeding, and protecting wild birds in general, and the direct propagation of those kinds amenable to such measures. Besides employing various lines of instructions, such as publications, inspections, correspondence, lectures, photographs, and motion pictures of wild bird life, the department has been enabled to secure and conduct a demonstration and experiment station in applied ornithology, which includes, among other branches, "game farming." This is at Amston, Connecticut, and is the property of Mr. Charles M. Ams, of New York City, who has placed it at our disposal, with generous aid in various ways. The tract embraces about three square miles of beautiful diversified country abounding in bird life, and is the natural haunt of a good variety of wild game. It includes a picturesque wooded lake more than a mile long, which wild fowl frequent, and also other smaller ponds. Here we have begun various lines of bird work, including the breeding of several kinds of game birds and of wild ducks. In a fenced pond and swamp, an enclosure of several acres, are kept fifteen species of wild ducks for propagation experiments, including a fine stock of canvasbacks.

The problem of wintering wild ducks in cold latitudes has always been a serious one, and this experiment station has already hit upon a method which furnishes a real solution. This is an aquatic house built on posts out from the shore of the pond. It is a simple structure, twenty-four by sixteen feet, boarded down into the water to within less than a foot of the bottom of the pond, thence with wire to a board sunk into the mud. It faces south, with four large frame windows in front and one on the west side. Within, two-thirds of the area is a swimming pool, the remainder a dry platform, on which the ducks come out to feed and rest. The sunshine pours in so effectively that the water never freezes although there is no artificial heat, and outside in midwinter the ice freezes two feet thick, with the mercury at times fifteen degrees below zero. The deep-water or diving ducks always have been the especial problem. If kept out of water during winter their feet are apt to freeze, and become sore and lame, as these birds are not well adapted to much walking. The new plan winters them and every other species in the most comfortable fashion. Even the most tender species, such as the blue-winged teal, thrive under it. I consider it very much better than to try to make the ducks live outdoors all winter in a little air hole in the ice which they keep open by swimming around all the time, getting frozen in during severe spells and needing to be chopped out in the morning, often with vitality greatly reduced by spring, making them unfit to breed. By this new plan they come through in splendid condition.

The department, during the summer, while the breeding and rearing are under way, gives instruction in practical details of propagation of game birds and wild waterfowl, and of attracting wild birds, and all persons who are interested in such matters and desire to learn are welcome to come to the game farm at Amston. It is planned during the coming season to hold regular summer school sessions. The tract has just been made a State Game Preserve and Sanctuary, one of the largest in Connecticut. All the propagation or "game farming," and the more important features connected with it, are within easy walking distance of Amston railway station, which is on the Air Line Division of the New Haven Railroad, between New Haven and Willimantic, ten miles from the latter. Those who desire it will be well cared for at the Amston Inn. The National Association of Audubon Societies has a residence at headquarters, called the "Audubon House," where visitors are received, and where are collections of pictures, and of mounted birds, also books and publications relating to bird life. The writer will gladly answer inquiries addressed to the New York office of the Association, 1974 Broadway, or to his home at West Haven, Connecticut.—THE AUTHOR.

*From *The Amateur Photographer and Photography.*

50,000 K.W. Turbo-Electric Generator

IN the turbine factory of the Allgemeine Electricitats Gessellschaft, a three-phase turbo generator has just been built having an output of 50,000 kw., corresponding to 75,000 h. p. and running at a speed of 1,000 r. p. m. The terminal pressure of the generator is 7,000 volts, and the exciter pressure 220 volts. One of the principal features of the set is that the entire steam output is developed in a single turbine, and the entire electrical output in a single generator. The weight of the turbine is 250 tons, and the weight of the generator 225 tons. The turbine has ten wheels from 3,400 to 3,800 mm. diameter corresponding to a peripheral speed of from 180 to 220 meters per second. The generator rotor has an external diameter of 2,200 mm. corresponding to a peripheral speed of 115 meters per second. The total length of the rotor of the generator is 9 meters, and the body of the rotor was built up from a large number of steel plates assembled on the shaft instead of being cut from the solid, as in the case of smaller machines built by the A. E. G. The manufacture of this large generator in war time has presented great difficulties to the makers, in view of the scarcity of raw materials. The blading of the turbine, for example, has been prepared without the addition of nickel to the steel, of which there is evidently a great scarcity in Germany. The transport of the turbo-generator to the power station where it will be used, has necessitated the use of a number of special railway wagons, the rotor being carried on a special double bogie car, each bogie having five axles.—*Engineering.*

Map Making for the Army

PROVISION is made in the American army for reproducing a limited number of maps by blue-printing and a larger number by lithography. A crude press, like an overgrown clothes wringer, is carried by each division. The plates are of zinc, and acid is used for graining as well as etching. With this equipment a plate 19 by 24 inches can be made in two hours or less, and prints taken from it at the rate of about 60 per hour. The results are surprisingly good. With 40 sketches a contoured map covering 48 square miles has been got up, and 120 copies printed in a single day, the error being less than one per cent. With the special engineer troops there are elaborate presses and the appliances of a lithographing establishment. The demand for maps is enormous, and the maps are being constantly corrected and brought up to date, showing changes made from day to day. Under normal conditions the map work of a division will require the constant services of at least one officer and 50 men from the pioneer regiment.

Hæmatoxylon Africanum

A SOUTH AFRICAN species of *Haematoxylon* was discovered in 1909 in Great Namaqualand, and consists of a shrub 1-1.5 m. in height, with yellow flowers and smaller leaves than *H. campea hianum.* Stems 0.5-1.25 inches in diameter consist mainly of a reddish-brown core surrounded by a nearly colorless layer of wood; this core, as in the case of log wood also, darkens on exposure to air. The color reactions of the extract resemble those of Brazilwood rather than those of logwood; it gives a brown with ferric chloride, not a black, and a pale pink precipitate with lead acetate, not a blue. Dyeing trials with *H. africanum* on mordanted wool show colors similar to those obtained with Brazilwood, but in all cases duller in shade and poorer in the red constituent. On this account it is of no technical importance. The slight difference in dyeing properties of *H. africanum* and Brazilwood may be due to impurities present in the former, but, on the other hand, it might be expected that a methyl ether of hæmatoxylin would dye shades almost identical in character with those of brazilin itself.—Note in *Jour. Soc. Chem. Ind.* on an article by A. G. PERKIN in *J. Soc. Dyers and Col.*

A Theory of Color Vision*

And the Selective Action of the Eye

By R. A. Houston, M.A., Ph.D., D.Sc., Lecturer on Physical Optics in the University of Glasgow

1. The eye is sensitive only to a limited range of wave-lengths in the spectrum, from 4,000 A. U. at the beginning of the violet to 7,600 A. U. at the end of the red. It is not equally sensitive to all the wave-lengths lying within this range, but there is a maximum on both sides of which the sensitiveness falls away rapidly. If the spectrum is a very bright one, this maximum lies in the yellow, but if the brightness is decreased it moves toward the green.

What is the cause of this selective action of the eye? It may be ascribed to the ultra-violet and infra-red radiations being absorbed by the substance of the eye, *i. e.*, the aqueous and vitreous humors and crystalline lens, before they reach the retina. But this explanation is at best only a partial one. It has been shown by experiment that the near ultra-violet and near infra-red are not absorbed by the substance of the eye, and thus, as Helmholtz points out, the selective action must be ascribed to something in the retina itself.

The selective action of the eye is analogous to phenomena occurring in many other regions of physics. For example, if we have two tuning-forks of the same pitch, and the first of these is sounded and held near the second, the sound waves strike the second and set it into vibration. There is then said to be resonance between the two forks. For resonance to take place in this case it is necessary that the pitches of the two forks should be very accurately adjusted to equality. The second fork thus exercises a selective action on the sound waves; if their pitch coincides with its own, it absorbs energy from them and is set into vibration, but, if their pitch is different from its own, it remains at rest.

In the same way, if a ship at sea is lying broadside on to the waves, and the natural period of rolling of the ship coincides with the period of the waves, the ship may be made to roll violently, even though the waves are comparatively small. For the effect of each successive wave is added to that of its predecessor, and the cumulative effect is great. But if the period of the waves does not coincide with the natural period of the ship, the effects of successive waves neutralize one another and the ship remains at rest. For example, the first wave may give the ship a motion to the right, and the second may strike it when it is coming back again through the equilibrium position, thus destroying the motion which the first wave has created. The ship thus exercises a selective action on the waves, taking energy only from those the period of which is approximately the same as its own.

The resistance of a selenium cell changes when the cell is exposed to the action of light. The change is found to be a selective one, dependent on the wave-length of the light. If the cell is stimulated in succession with monochromatic light of different wave-lengths, and the change in resistance noted and plotted as a function of the wave-lengths, the curve is found to have a maximum for one particular wave-length and to fall away on both sides of this maximum. The change can be explained by supposing that in the selenium cell there are electrons capable of executing vibrations about positions of equilibrium. These electrons are set into vibration by the incident light wave, and the amplitude of the vibrations is greatest when the period of the incident light coincides with the natural period of the electrons. When the amplitude passes a certain critical value, the electron breaks free from the point to which it is attached, and the increase in the number of free electrons causes the increase in the conductivity.

Now these three cases—tuning-fork, rolling ship, vibrating electron—are all represented mathematically by the same equation, namely the equation of the forced vibrations of a pendulum, though in the different cases different physical meanings are attached to the symbols involved. It seems reasonable, therefore, to attempt to explain the selective action of the eye in the same way. We shall do so here, and shall begin by giving an account of a piece of apparatus that gives forced vibrations and describing some experiments made by it. Thus by means of a model we shall obtain the results of the mathematical theory without having any recourse to mathematics at all.

2. AB is a compound pendulum consisting of a long thin brass rod with a knife edge and a cylindrical weight C. The length of the rod is 148 cm. and its diameter is 6 mm. The weight was made by filling a brass cylinder with lead. It can be moved up and down, and clamped in any position on the lower half of the rod, and thus the period of the pendulum can be altered from 1.60 to 2.40 sec. EF is a simple pendulum consisting of a ping-pong ball hung by a thread. This thread is attached to a wire DE, which is fastened to the rod by a spring clip at D. The wire DE, which is fastened to the rod by a spring clip at D. The wire DE is parallel to the edge of the knife-edge.

The length of the simple pendulum was kept constant and its period was 2.03 sec. It is so light in its component parts that its vibrations do not appear to affect the motion of the compound pendulum to an appreciable degree.

Fig. 1

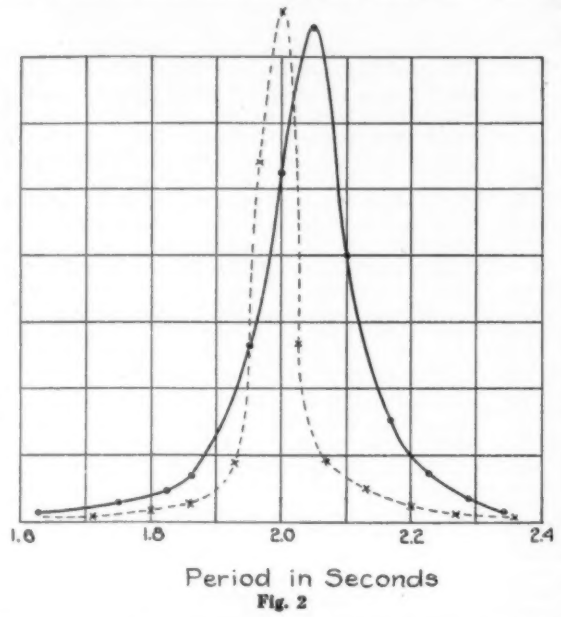


Fig. 2

The following experiment was made with this apparatus: the cylindrical weight was clamped high up so that the period of the compound pendulum was 1.63 sec. The compound pendulum was then drawn aside, so that it came against a wooden peg in a position making an angle of about 3 degrees with the vertical, and held until the simple pendulum was perfectly at rest in a vertical position. It was then let go and commenced to execute vibrations. The amplitude of these vibrations remained practically constant throughout the course of the experiment. The point of support E of the simple pendulum participated in the motion of the compound pendulum, and thus the simple pendulum was set into vibration. A horizontal scale not shown in the diagram was fixed up close behind the thread parallel to the direction of motion, and the maximum value of the amplitude read. The cylindrical weight was then clamped in another position and the measurement repeated. The initial angle of the compound pendulum was the same in each case.

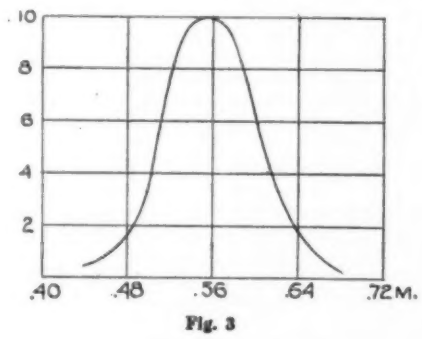


Fig. 3

The results are represented by the smooth curve in Fig. 2. The abscissæ give the period of the compound pendulum, and the ordinates the square of the maximum amplitude is plotted instead of the maximum amplitude itself, because the former, not the latter, is proportional to the energy acquired by the simple pendulum. The curve has a maximum at 2.05 sec. falling away rapidly on both sides of this. In the experiment recorded in the diagram, the spring clip was attached a distance of 6 cm. below the knife-edge. The relative value of the different ordinates does not depend on the position of D, but their absolute value does, *i. e.*, if the distance of D below the knife-edge is increased, the ordinates of the curve would increase everywhere in the same ratio.

After the experiment with the ping-pong ball was completed a similar one was carried out with a simple pendulum consisting of a small "marble" at the end of a thread. This time the clip was attached at a point 4 cms. below the knife-edge, and the period of the simple pendulum was 1.99 sec. The results are represented by the dotted curve in Fig. 2, but on only half the vertical scale that the other curve is plotted on. If they were plotted on the same scale, the maximum ordinate of the dotted curve would be more than twice the maximum ordinate of the smooth curve.

Both the curves are of the same type, the difference being that the dotted one is narrower. This is because the marble offers less resistance to the air than the ping-pong ball. The smaller the frictional resistance, the narrower the curve, and consequently the more perfect the resonance.

3. Now let us apply the curves shown in Fig. 2 to the explanation of the selective action of the eye. Let us suppose that the energy of the compound pendulum represents the energy of the light wave, that in the retina there are a great number of oscillators or vibrators to perform the function of the simple pendulum, and that the energy of the simple pendulum represents the part of the energy of the light wave taken up by the eye.

Fig. 3 is taken from a paper by H. E. Ives,[1] and represents the sensitiveness of the eye to light of different wave-lengths. We learn from it, for example, that if the same quantities of energy are in succession changed into light of the wave-lengths 6,400 A.U. and 5,600 A.U., the luminosities of the sensation produced will be in the ratio of the numbers 1.7 and 9.8. The curve gives the mean of the results for 18 observers, and the field of observation had the brightness of a magnesium oxide surface undergoing an illumination of 25 meter-candles and viewed by an eye in which the pupil is at its normal aperture. If we compare Ives' curve with the two curves shown in Fig. 2, we find it is broader than they are. They can be made broad enough by increasing the frictional resistance to which the simple pendulum is subject, but the shape does not then agree very well; the maximum of Ives' curve is smoother and not so pointed as they are. If, however, we assume that the vibrators in the eye have not all the same period, but that their periods vary about a mean value, which is itself in the yellow, we can represent Ive's curve perfectly.

The question arises as to the nature of the vibrators. It is possible, though not essential to the explanation, that they are electrons, and that, when they vibrate too far and break free from the centers to which they are attached, the change occurring is to be identified with the bleaching of the visual purple.

Sir William Abney[2] likens the color-perceiving apparatus in the retina to three pendulums, one for each primary color. Thus he would regard Ives' curve as due to the sum of three curves, one representing the amount of energy taken up by the mechanism that produces the red sensation, one representing the amount of energy taken up by the mechanism that produces the green sensation, and one representing the energy taken up by the mechanism that produces the blue sensation. We shall leave the question as to whether there is only one or whether there are three classes of vibrators in the retina open at present, and shall proceed to a further study of experimental results obtained with the apparatus shown in Fig. 1.

4. A clockwork kymograph—an apparatus consisting of two drums over which a band of smoked paper passed with a uniform speed—was lent me by the Physiology Department, and I endeavored to obtain records of the motion of the simple pendulum. They did not prove very successful as long as a single thread was employed, but when the simple pendulum was replaced by a short brass cylinder suspended by two threads GH and EF, one

*A non-mathematical account of a theory which has already been described in the *Proc. Roy. Soc.* A. 92, p. 424, 1916. From *Science Progress*.

[1] *Phil. Mag.* (6), 24, p. 860, 1912. The curve has recently been verified and extended by P. G. Nutting, *Phil. Mag.* (6), 29, p. 301, 1915.

[2] *Tyndall Lectures on Color Vision*, pp. 36-9.

at each end, and a short thread HP was allowed to trail a metal point P on the smoked paper, which was passing in the direction shown by the arrow, no difficulty was experienced. Fig. 5 gives two records, both, of course, reduced in size. The original was in each case about 24 inches long. For the upper curve the period of the compound pendulum was 1.93 sec., and for the lower curve it was 2.105 seconds. In each case the period of the simple bifilar pendulum was 2.00 seconds. Both records show the simple pendulum starting from an approximate state of rest.

The vibrators in the retina are not allowed to pursue their motion undisturbed. They may start from rest, but before many periods have elapsed they may break free from their points of attachment, or they may be brought to rest by an impact. Thus as typical of their motion we may take a piece of one of the curves given in Fig. 5. I have studied two portions of the lower curve very carefully, namely from the end of the first to the end of the ninth inch, and from the end of the first to the end of the 21st inch. The first portion gives the rise of the amplitude from zero to its maximum value. The second portion gives practically the whole curve.

According to Fourier's integral theorem, any curve may be represented as the sum of an infinite number of sine curves. In the special case here considered when the original curve is approximately periodic, although sine curves of all possible wave-length take part in its composition, those with approximately the same wave-length as the original curve have much the greatest amplitude. For example, the wave-length of the original curve, as obtained with the kymograph, seemed about 1.7 inches. It can consequently be regarded as due to the superposition of sine curves of wave-length 1.0, 1.1, 1.2, 1.3 up to 2.4 inches, the sine curves in the middle of the range having the greatest amplitudes. If we take the constituent sine curves twice as close, *i. e.*, every twentieth inch apart, when added together they will reproduce the original curve with greater accuracy.

Just as the original motion may be regarded as built up of an infinite number of sine motions, the energy of the original motion may be regarded as distributed over these different sine motions. Lord Rayleigh has shown how to calculate the proportion that falls to each.[3] I made the calculation for both the 8-inch length and the 20-inch length of the lower curve in Fig. 5. It was rather a tedious calculation, but as the details of the procedure may be interesting, I describe them in the following paragraph with special reference to the 20-inch length.

The curve was reproduced on squared paper, divided in tenths of an inch, and the value of the ordinate measured every tenth of an inch. This gave 200 figures. These were then arranged in 15 sets, in rows of tens, elevens, twelves, etc., up to twenty-fours, the rows of each set being arranged above one another; for example, the elevens gave 18 rows of eleven and one row of two, and the set was arranged so that they formed two columns of 19 and nine columns of 18. Each column was then added. In the case of the elevens we had eleven results; these eleven results were multiplied in succession by cos 0, $\cos\frac{2\pi}{11}$, $\cos\frac{4\pi}{11}$, etc., the results added and the sum squared, they were then multiplied in succession by sin 0, $\sin\frac{2\pi}{11}$, $\sin\frac{4\pi}{11}$, etc., the results added, and the sum squared. The two squares were then added. The result is proportional to the energy belonging to the wave length 1.1 inch. The other sets were treated similarly. In the case of the 8-inch length the procedure was the same, but only the first 80 ordinates were required.

The results are shown in Fig. 6. The dotted curve gives the energy distribution for the 20 inches, and the smooth curve the energy distribution for the 8-inch. The vertical scale is ten times as great for the smooth curve as for the dotted curve. As mentioned above, the wave length of the curve seemed from inspection to be about 1.7 inch. If the period during which the amplitude is attaining its full value is taken by itself, however, most energy is associated with the wave-length 1.5 inch. The dotted curve has two maxima, one at 1.5 inch and the other at 1.78 inch.

5. Let us now apply the results of the preceding section to the eye. We have postulated vibrators in the eye to take up the energy of the light wave; we must also postulate a nerve to carry the energy from the eye to the brain. The preceding section shows that no matter how monochromatic the incident light is, the motion of the vibrator will not be monochromatic, but its energy will be distributed over a range of wave-lengths; for example, if the incident light is yellow, the motion of the vibrator when analyzed will contain also some red and green. Consequently the energy passing along the optic nerve to the brain will be distributed over the red, yellow and green with a maximum in the yellow. No matter how monochromatic the incident light is, the impression on the brain is not monochromatic.

The arrangement may be compared with a telephone. The vibrators in the retina play the rôle of the diaphragm in the transmitter which takes up the sound waves, and the optic nerve plays the rôle of the telephone wire. There is, however, one important difference. When a musical note is sung into the telephone, it is transmitted correctly along the wire, because the diaphragm reproduces the sound wave accurately. In the eye the vibrators do not reproduce the wave accurately. It is as if the diaphragm in the transmitter were subjected

Fig. 4

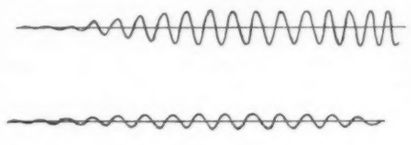


Fig. 5

to disturbing influences of such a nature that the person at the other end hears a medley of musical notes over a range of half an octave on each side of the note originally sung into the transmitter.

Any arrangement of molecular dimensions for taking up the light wave must have some such modifying effect upon its character. This fact has hitherto escaped notice, but must receive attention as the modern views as to the nature of white light become more prevalent. The sine curve of uniform wave-length extending from negative to positive infinity was an abstraction, and has given rise to erroneous ideas.

Suppose, now, that the eye is simultaneously excited

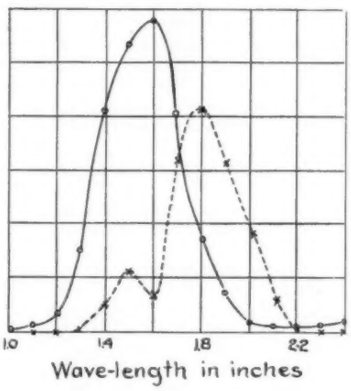


Fig. 6

with monochromatic red and monochromatic green light, say lithium red and thallium green. Then two disturbances travel along the optic nerve, one which has an energy distribution given by the full curve on the right in Fig. 7, and one which has an energy distribution given by the full curve on the left. If we add the ordinates of these two curves, we obtain the dotted curve, which has its maximum at a point between the Tl and Li lines in the spectrum. *e. g.*, in the yellow. Thus red and green combine to form yellow. In the figure the two component curves are drawn the same size. If the thallium curve has all its ordinates increased in the same ratio, the maximum of the resultant curve is moved toward the

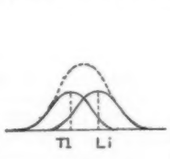


Fig. 7

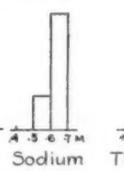


Fig. 8

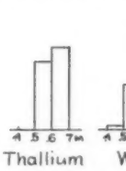


Fig. 9

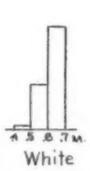


Fig. 10

green, *i. e.*, if the proportion of green in the mixture is increased, the yellow becomes greenish. This is as it should be.

According to my view the energy curve, *i. e.*, the curve representing the distribution of the energy over the spectrum *after* it is taken up by the vibrators, is characteristic for the light impression on the brain. We are accustomed to associate three qualities with a light impression, namely luminosity, hue, and saturation. The area of the curve gives the luminosity of the impression, the position of the maximum the hue, and the narrowness of the curve the degree of saturation.

We have hitherto left the question open as to whether there is only one or whether there are three classes of vibrators in the spectrum. We have found, however, from a study of our model, that one class is quite sufficient to explain the phenomena of color mixing. The only justification for other two classes would be to satisfy a supposed need in this direction. But as it is non-existent, other two classes are superfluous. The three-color theory of vision is consequently false if it is taken to mean that there are three independent primary sensation or three independent visual components, one or two of which are wanting in color blindness.

In *An Introduction to the Study of Color Vision*, J. H. Parsons states that the three-components theory becomes less plausible the more concrete the form it takes. Young suggested three different types of nerve-fibers, others have suggested three substances which undergo chemical change, and others again have suggested electrical change. If the details of any of these hypothetical processes are worked out, and due regard is at the same time paid to the selective action of the eye, I think it will always be found that two of the three components are superfluous.

But, it will be asked, how does my theory explain the apparent trichromatism of ordinary vision? We may here fall back on the explanation of Dr. Edridge-Green, namely, that the color-perceiving center in the brain is not sufficiently developed to discriminate between the characters of adjacent curves. Two curves must be widely different in shape and position before the color perceiving center can detect the difference.

We can consequently regard each energy curve as equivalent, as far as the color perceiving center in the brain is concerned, to one, two, or three rectangles. For example, Figs. 8, 9 and 10 represent a sodium yellow, a thallium green, and a white light of equal luminosity. The areas of the rectangles may be regarded as the amount of stimulation of the three primary sensations of the Young-Helmholtz theory. Indeed I took the value of the ordinates from one of Sir Wm. Abney's curves, merely exaggerating the third component in Fig. 10 to make it visible. So all the data of the three-color theory may be utilized. But Figs. 8, 9 and 10 do more than represent the results of the three-color theory. They are energy curves, crude ones it is true, but sufficiently representative for the discriminating power of the color perceiving center of the brain. The sides of the rectangles have been placed at .4, .5, .6 and .7 in the diagram, but this is not essential.

Color blind persons may resolve their curves only into two rectangles, and it is possible that under certain circumstances specially gifted persons may resolve theirs into four rectangles, in which case the ordinary representation of the results of color mixing by the positions of points on a plane would fail to hold. It would be difficult to establish a failure of this construction, however, since the experimental results are never very accurate. It is interesting to note that Burch[4] is inclined to predicate four visual components.

Instead of accounting for color blindness by a want of discriminating power in the color perceiving center of the brain we may ascribe it to excessive disturbance of the vibrators in the retina. This would make the energy curves widen out and lose their distinctive form.

The color of the sensation produced by monochromatic stimulation varies with the intensity of the latter, becoming whiter for high intensities. This follows naturally from the theory developed here; when the amplitude of the vibrators is increased, they will be subject to more disturbance, and their motion will consequently be more irregular. Hence its energy will be more widely distributed over the spectrum.

Definition of Horse-Power

THE horse-power was defined by Watt as being 550 foot-pounds per second without consciousness of the distinction between standard and local foot-pounds. To obtain the exactness which is our present object, there must be an additional specification. An exact definition has been adopted by the Bureau of Standards (Bulletin 34) which has been in some use for many years. This makes the horse-power equal to 746 watts. A watt is 10^7 times the work of an erg per second. An erg is a dyne acting through a cm. (0.3937 inch). A dyne is a force which gives a gram an acceleration of a centimeter per second per second.

A standard foot-pound per second is the work done per second by a force of a standard pound acting through a foot. A standard pound is a force which gives a pound (453.59 grams) an acceleration of 980.665 cm. per second per second. Hence there are

$$\frac{746\times10^7\times0.3937}{980.665\times453.591\times2}=550.22$$

standard foot-pounds per second in a horse-power. The Bulletin referred to shows that this gives 550 London foot-pounds where Watt made his original definition. —*Electric Review.*

[3] *Collected Works*, vol. iii., p. 268.

[4] Parsons' *Color Vision*, p. 115

Notes on Testing Hardness of Metals*

The Right Use and Application of Methods

By J. W. Craggs

In the mechanical testing of metals the determination of hardness is of considerable importance, because of the comparative reliability of the results and the ease with which it may be carried out. But the endeavor of the engineer and metallurgist to express in values some definite property, useful for their special needs and related to hardness, has caused them to give a meaning to the term not understood or used by mineralogists or laymen. To these it means simply that property which denotes resistance to penetration; while to the engineer it may mean abrasive, cutting, elastic, or tensile hardness. It is quite right that the engineer should endeavor to find simple tests that shall indicate to him the behavior, in actual use, of the material under consideration, but he causes confusion if he groups all the different properties which he so uses under a term, such as hardness, to which a definite meaning is already appropriated. The object of these notes is to discuss the right use and application of the methods at our disposal for testing hardness. Many of the tests are of great importance in indicating specific properties, and efforts should be made strictly to limit the use of these tests to those instances where practice has upheld their utility. It would then naturally follow that instead of the results being loosely termed "Hardness numbers" they would be given a nomenclature indicating the property determined.

The methods used may all be grouped as:

(1) Indentation tests, whether (a) gradual, or (b) sudden.

(2) Abrasion or scratch tests.

Though Wahlberg extends this classification to a third, in which he places Foeppl's method, the latter should rightly be placed under indentation tests. These depend on the permanent distortion of the material, under pressure, by means of a hard steel ball, cone, or knife edge; and the abrasion or scratch tests on the material removed from the surface during sliding contact with another body of such superior hardness that its surface remains unimpaired by the action.

As the tests that have been introduced are so numerous it is impossible to note more than two or three in each group, and attention will therefore be given to the following:

(1) *Indentation tests.* (a) Brinell test. (b) Shore's scleroscope. (c) Pellin test.

(2) *Abrasion or scratch tests.* (a) Turner's sclerometer. (b) Martens' sclerometer. (c) Saniter's abrasion test.

Brinell test.[1] Brinell's machine is most widely used today. In this method a hardened steel ball capable of resisting deformation is pressed into the face of the metal to be tested. The spherical area of the indentation being calculated, and the applied pressure being known, the stress per unit area may be determined, thereby giving the hardness number. The results are, within limits, independent of the size of the ball and the pressure applied. The sample for test need only be small, and the actual operation occupies two or three minutes to perform. Two types are in common use: one of Swedish make known as the Aktiebolaget Alpha—a ball test; and the Martens, in which a conical indentation is produced and the pressure exerted by means of water and not weights as in the former. The Martens machine finds support in that the cones can now be prepared with sufficient accuracy to secure consistent results, and the depth of conical indentation possesses advantages in calculating. In the ball test a 10 mm. ball is most commonly used with a weight of 3,000 kilos. for steels, and 1,000 kilos. or even 500 kilos. for brasses and comparatively soft alloys. In investigations of a particular class of material it is advisable to use the same sized ball and equal pressures throughout where comparisons are being made.

Shore's Scleroscope.[2]—In this instrument a small steel cylinder or "hammer," with a hardened or diamond point, is allowed to fall from a height of about 10 inches upon the polished surface of the metal to be tested. The hardness is measured by the height of the rebound and for this purpose the tube is graduated into 140 divisions so that hardenite gives a reading of approximately 100. It follows that readings exceeding 110 are only given by materials of unusual hardness. One advantage possessed by Shore's scleroscope is its convenience. It is small and may readily be carried for the testing of any sample large or small. The indentation produced might pass unobserved and could, therefore be made on a finished article, for the area of the indenting point is stated to be only $\frac{1}{11000}$ of a square inch.

Pellin Test.—This, at first sight, appears to be a combination of the preceding tests; it is, however, based on the Brinell method and has been designed for the testing of the different metals used for all industrial purposes. It is essentially one in which the indentation is produced by a falling bar of known weight, having at the lower end a steel ball 2.5 mm. in diameter. The apparatus is arranged so that instant release may be obtained by an annular electro-magnet carried by a housing in which the bar slides freely. When in position for use the bar is retained there by the magnetic attraction of the soft iron collar, fitted to it, to the magnet on the housing. The diameter of indentation may be varied by means of weights placed on the top of the bar or by altering the distance of fall. When the impression has been made its diameter is measured and, knowing the weight used, the hardness number may be calculated.

Turner's Sclerometer.[3]—By this device a standard scratch is produced on the polished surface of the metal. A weighted diamond point is drawn once forward and once backward, and the hardness number is the weight in grams required to produce the standard scratch. Turner describes this as one just visible to the naked eye as a dark line on a bright reflecting surface, or as a scratch which can just be felt with the edge of a quill when the latter is drawn over the smooth surface at right angles to a series of such scratches made by regularly increasing weights. Of the many forms of sclerometer it is that most generally used.

Martens' Sclerometer.—Here the scratch is varied and the weight is kept constant. The usual load is 20 grms. and the point is stationary, while the specimen is drawn backward and forward by a traversing table. The determination is made by a careful measurement of the width of scratch, on the horizontal polished surface, by means of a microscope with micrometer eye piece, or by photographing the scratch under a known magnification. The hardness number is the reciprocal of the width of the scratch in millimeters.

Saniter's Test.[4] Devised particularly for the determination of the wearing property of rail steel, this method attempts a reproduction of the actual stresses encountered in use. The test-piece is 5 inches long by 0.5 inches diameter and is fixed in a chuck which revolves at 4,000 revolutions per minute. Near the free end the test-piece rotates by friction the inner ring of a ball bearing which is loaded to produce a pressure equal to 205 pounds at the point of contact. The length of this contact section is $\frac{11}{16}$ inch and the total number of revolutions made by the test-piece 200,000. One test occupies about 50 minutes. The wear number is the ten-thousandth part of an inch removed from the diameter of the bar during the test. To ensure accuracy Saniter recommends that the test-piece be measured in three places, and also in a plane at right angles, making six measurements in all, the average being taken as the correct number. These are all recorded before as well as after the test, for even in the original test-piece slight irregularities may occur. The smallest wear number represents the least wear, and consequently the best wearing steel. The test-pieces are always taken in a longitudinal direction relative to the actual rail.

VALUE OF THE TESTS IN PRACTICE

Confidence in the Brinell method for constructive, ductile materials, as a measure of the tenacity, is now general, as evidenced by its extensive use in engineering practice. It is very easily applied and when used correctly may be said to give definite results. Adopted originally for ordinary carbon steels, its application has been extended to special steels, and to alloys of the non-ferrous type, and if data be collected for each class of material the results can be used with certitude. McWilliam and Barnes[5] have examined steels of varying carbon content in the presence of 2 per cent chromium and 3 per cent nickel, and also with 0.2 per cent vanadium. In all three types of steel they found the factor for the conversion of the Brinell number to the maximum stress to vary, though the variation was small. Their factors were chrome steels, 0.242; nickel steels, 0.239; and vanadium steels, 0.235. From these it may be observed that where a particular type is being regularly handled the factor may be determined and constancy obtained, whatever the carbon content or the physical condition.

Knowledge of the material is an important reservation that one must note in seeking to apply the method. The general application to all alloys—ferrous and non-ferrous—without definite information of the type, involves liability to discrepancies, *e. g.*, with a cast cartridge metal, which is entirely α, the factor is in the neighborhood of 0.28—0.30; while with a brass of the Muntz metal class, in which there are practically equal portions of α and β, it is from 0.25-0.27, and, in the case of an all β brass, approximates to 0.24-0.25. Such figures, of course, are only directly applicable to the copper-zinc series of alloys. The addition of a third element, say aluminium or manganese, to adjust the structure so as to give a particular type, would necessitate further investigation in the determination of special characteristics even though the micro-structure be identical with that of a pure copper-zinc alloy. With samples in which the structure is so small that numerous grains are included in the impression made by the ball, their different orientation will eliminate variations in the test, but with large grains this is not so. Appreciable disturbance is caused, so that in samples which possess a coarse structure, whether of a simple or complex nature, the character of the impression will depend upon the orientation of the crystal grain on which such an impression is made. Actual determinations made on two adjacent crystal grains gave unsymmetrical impressions of different forms that could not be measured. Similarly with a test on the crystal boundary the irregularities were such as to prohibit any comparison being made. We may conclude that metals and alloys possessing a coarse structure will tend to give unreliable results and may even be such as to prevent an approximation being made. This irregularity in the indentation is not usual with all soft or ductile materials, though other workers have had at times a similar difficulty with the ball test. It was in this instance probably accentuated by the coarseness of the crystals, resulting in a condition in which slipping within the crystal was more easily induced.

With hard and brittle materials the Brinell test is of much less value. This fact is obvious if one thinks of the determination as giving, in a sense, a measure of the viscosity of the solid, for flow must take place. The indentation due to the pressure by the ball or cone is produced by compression, shearing, and translation along gliding planes. In a ductile body this readily occurs. With a hard alloy fracture may occur at once or after a short interval, the crack or cracks radiating from the point of test.

Again in testing hard material cracking may not take place and yet the determination may be unsatisfactory, for the balls, which contain approximately 1 per cent of of carbon, 1.5 per cent of chromium, 0.2 per cent of nickel, and are oil-quenched from 800° C., only possess a limited rigidity. When distortion of the ball is observed the impression made by it will not give a true figure. To show the unreliability of tests in which the Brinell number is recorded as 730 to 750, and in some instances still higher, chrome, nickel-chrome, nickel-chrome-vanadium, and high-speed steels were hardened and determinations made. Several balls were tried and in each case there was distinct flattening of the ball. The highest figure recorded was 653. In many instances, as will be noticed below, the maximum reading was 625.

Apart from these limitations, this test may be rendered valueless by careless manipulation, especially in regard to the time factor. Thomas[6] has shown that differences may be recorded by varying the time of application of the pressure up to 8 or even 10 minutes, when testing mild steel. The differences, however, are only slight after one minute and he, therefore, urges the adoption of this as the standard time for the test. The thickness of the sample must also be such that stresses set up by the ball are dissipated before penetrating throughout the full depth of the piece. Many experiments led him to declare that 0.38 inch should be the minimum when a normal load of 3,000 kilos. is used. If the thickness chanced to be from 0.15 to 0.20 to 0.38 inch the load should be less say 1,000 kilos for satisfactory results; while an interesting series of tests with thin pieces backed first by hard steel, and secondly by wood, showed that it was essential to support the sample by material as hard as or harder than the test-piece, otherwise the results were variable.

Many apparently strange results may be explained by the differences in the amount of cold-work that will produce "overstrain" in various alloys. With certain of the high tenacity light alloys, for example, the amount of

*From the Journal of the Society of Chemical Industry.

[1] Rapp, Congr. intern. Methodes d Eddai. Paris, 1900. Wahlberg. Journ. Iron and Steel Inst., 1901, I., p. 243.

[2] A. F. Shore, Scleroscope, Amer. Mach., 1907, 30, Part 2, p. 477.

[3] Turner. Proc. Birmingham Phil. Soc., 5, Part 2.

[4] Saniter. Journ. Iron and Steel Inst., 1908, III., p. 73.

[5] Journ. Iron and Steel Inst., 1915, 91, 125.

[6] J. Iron and Steel Inst., 1916. I., p. 255.

cold-work possible is very small for each annealing, while with others a considerable amount of work can be done. From this fact it may be observed that where large indentations are made through excessive loading, the hardness numbers may be misleading. A standard load should be adopted for each individual class of alloy.

In using the Shore scleroscope some property other than the tenacity is indicated. If in falling the "hammer" produced no indentation a true measure of the elasticity would be given, but in practice this does not occur. Yet the penetration is so small that the result gives usually an approximate measure of the elastic limit. The figures are of great value when the nature and properties of the alloy under examination are familiar; or if a measure of the cold-work that has been applied is desired, for the test exhibits most strongly the "hard worked" or "écroui" condition. Probably this is due to the more rapid increase in the elastic limit than in the maximum stress, when work is applied, for the Brinell number does not increase at the same rate. It is because of this characteristic of the scleroscope test that many investigators find no proportionality between it and the Brinell test.

Generally, in the cast or normal condition a rough comparison of the Brinell and scleroscope numbers may be made by the use of the following factors, which have been calculated from hundreds of tests performed.

Ordinary carbon steel, Scleroscope No. $\times 6.67$ = Brinell hardness No.

Nickel and nickel-chrome steels, Scleroscope No. $\times 7.0$ = Brinell hardness No.

Cast iron and bronzes, Scleroscope No. $\times 5.25$ = Brinell hardness No.

Aluminum and light alloys, Scleroscope No. $\times 6.0$ = Brinell hardness No.

It must be understood, however, that these factors should not be used carelessly: a knowledge of the physical condition of the metal is essential. In the paper by McWilliams and Barnes, already cited, it is declared that there is no constant factor for the scleroscope and Brinell tests in alloy steels. This conclusion is, perhaps, the better for scientific purposes, for each test is a measure of different properties. The above factors exhibit the general trend of the results and are only of value if correctly applied.

Experiments made with a view to determining the difference shown in the hardness by the Brinell, scleroscope, and simple scratch tests on a sample of nickel-chrome steel gave the following interesting results:

Quenching medium.	Temp.	Brinell.	Scleroscope.	File test.	Glass test.	Rose quartz test.
1. Rape oil	800	625	80	No mark.	Scratched with ease.	With difficulty.
2. Cold water	800	625	80	"	"	With great difficulty.
3. Boiling water	800	625	80	"	"	"
4. Contact with cold iron slab	800	625	80	Just bites.	"	With ease.
5. Strong air blast	800	625	77	No mark.	"	With difficulty.
6. Spray of cold water	800	625	77	Great difficulty.	"	"
7. Concentrated sulphuric acid	800	625	74	No mark.	"	"
8. Spray of water; face of sample at 800° C. with core at 600° C.	800	625	75	Great difficulty.	"	Just marks.

The "file hardness" test was made with a new 8-inch dead smooth feather-edged file for each test. The "glass hardness" test was applied so that the edge of the sample was drawn over the face of a piece of highly-polished plate glass. The "quartz" test was made in a similar manner to the file test, with crystals of rose quartz.

These results show no variation in the Brinell numbers and practically none in the scleroscope figures. The former test indicates practically the maximum obtainable by such a test and in each case a new ball was used. The scleroscope test, being an indication of the resilience or elastic hardness, shows slight variations, though test No. 4 is remarkable as exhibiting no change, while the quartz scratched the sample with ease. No doubt the hardness is best measured by resistance to penetration, but the actual value varies according to the mode and rate in which the test is made. Each test has its own definite value, as suggested above, and should be applied accordingly.

Sufficient data have not yet been collected to determine the true value of the Pellin test, and no generalization can be made with any certainty. The principle on which the test depends, its simplicity, and the rapidity with which it may be carried out, suggest for it an important future. The smaller indentation gives probably an advantage over the Brinell method.

The sclerometer methods mentioned give better values than the above tests of the absolute hardness of the material. But, as Howe has mentioned, considerable difficulty is encountered in registering the dimensions of the scratch after it is obtained; while Turner confesses that the standard scratch is only definitely recognized after some experience. From the standpoint of works value the Brinell, scleroscope, and Keep's drill tests are the best for manipulation; yet the sclerometer should be used for its intrinsic worth. The penetration hardness is a property not indicated or measured by any of the others.

The abrasive hardness is now measured by Saniter's test. He has shown the lack of uniformity between the wearing properties and the Brinell hardness numbers. The test follows more closely than the others, in a simple fashion, the actual stresses the material will have to withstand in practice. A good example of the need of such a test is shown in the case of Hadfield's manganese steel. With a Brinell number of about 200 it would (if judged by a standard Brinell figure) be declared soft, yet it withstands abrasion excellently and is specially suited for work where first-rate wearing properties are essential.

Another instance in which some test other than the Brinell is necessary is in the determination of the cutting efficiency of tools. Inspectors often stipulate a standard Brinell hardness and reject or pass the tool on the figure. The cutting efficiency depends upon the stability of the constitution of the hardened steel over a wide range of temperature and is not related to the Brinell number in any way. A Brinell number may be as specified and the tool fail in practice.

The Brinell test gives a measure of the tenacity; the scleroscope an approximate measure of the elastic limit; the sclerometer gives the penetration hardness; while the Saniter test indicates the wearing properties. The determination of the machining hardness, the cutting efficiency, etc., must be conducted by other means. If better terms for the different hardnesses could be adopted to prevent overlapping and confusion in the tests, there can be no doubt that greater progress in their development and more extended use would follow. I suggest that with this object the following be adopted: for Brinell hardness, the "tenacity number"; for scleroscope hardness, the "resilience number"; for sclerometer hardness, the "penetration number"; and for the Saniter test, the "abrasion number." The terms are perhaps not the best that could be devised, but something along the line suggested should be attempted.

The Solar Surface

LECTURING at the Royal Institution, upon "Recent Investigation of the Superficial Layers of the Sun," a rind something like 5,000 miles in thickness of a sun of a radius of 430,000 miles, Prof. H. F. Newall, director of the Solar Physics Observatory, Cambridge, remarked in the first lecture that theory had to explain, among other things, why the spectrum lines from different parts of the sun differed greatly in intensity, why sunspot spectra contained lines (due to vanadium), not observed in other spectra, why the spectrum of the limb taken during an eclipse showed bright lines (flash spectrum), not dark lines, and why the sun seemed less bright near the limb than in the center. The latter fact was ascribed to the "dusty veil" (the corona) which, if close to the sun, would, he said, affect the solar phenomena as our own atmosphere modified the appearance of the sun at sunrise and sunset, much more than if further away from it. The perplexing partial or total reversals of spectrum lines had correctly been explained by Kirchhoff in 1860, in the light of knowledge of those days concerning absorption and emission and a perfect radiator, but our knowledge of black-body radiation and energy distribution over the spectrum was of recent date, and the important influence of scattering had only been shown by A. Schuster since 1908; these factors affected the distribution over the solar surface of light of different wave-lengths to various degrees. In the second lecture, Professor Newall dwelt particularly on the photographic study of the sun with the aid of the spectro-heliograph in light of particular wave-lengths. When the apparatus was moved across the sun, an image of the whole sun was built up of many chords or narrow strips taken successively. The particular lines chosen were the K-lines of calcium and the hydrogen lines (H α red, Hλ blue). Careful examination of the photographs obtained revealed strong differences, when the lights (in which the photographs were taken), differed only little in wave-length, and the photographs suggested an enormous complexity of the structure, accounting for the apparently contradictory statements of earlier observers. Vapors of calcium and hydrogen and other substances were moving upward in some places, downward in others; the instruments and methods allowed us to distinguish layers from different altitudes of the solar atmosphere; as the vapors ascended they spread out in mushroom fashion, while the gas pressure diminished, and the lines from the uppermost layers might appear complementary to those from intermediate layers. But the information from the center and from the edge of the sun finally led to the same conclusions. The gas pressure could be judged from the breadth of the lines which increased with the pressure. By taking photographs of the same part of the disc at intervals of a few minutes, Hale had obtained stereoscopic effects, and his photographs showed that sun spots were surrounded by enormous vortices, clockwise and anti-clockwise on different sides of the equator, and that the sun as a whole was a magnet like the earth, while the dissociated ions (at 5,000 degrees or 6,000 degrees C.) of the vortices would set up powerful local magnetic fields. With the aid of his velocity recorder Deslandres had obtained another type of photographs of the solar disc on each of which thousands of lines and their displacements and reversals could be studied. Working in similar ways, St. John (at Mount Wilson Observatory), concluded that the K_2 line of calcium vapor showed in general a rising movement, the K_3 line a descending movement, in addition to lateral movements; but Professor Newall did not accept that interpretation. Evershed, at Kodaikanal had recently observed that sun-spot lines were always slightly displaced with respect to the same lines in the neighborhood, and that the actual displacement depended upon the direction of the slit (of his apparatus) with respect to the center of the disc; there was no shift on a spot at the solar center. Attention was also drawn to the connection between the dark filaments or tails and the sun spots, into which they seemed to be drawn, and also the prominences, according to Hale, Deslandres, Ellerman and others. Concluding, Professor Newall said that the observations on the sun and stars kept the astronomer on the right lines as to the interpretation of the smaller phenomena studied in the laboratory. —*Engineering.*

Fuel Economy in Blast Furnaces

PARTICULARS are given of the working of the blast-furnaces at the Skinningrove Ironworks since 1880. At that time the output was considerably less than the average of the furnaces in the Cleveland district. To discover the cause, experiments were made on a model furnace 1-48th full size, with all conditions, including the coarseness of the charge, reduced on the same scale. The model was cut vertically into two equal portions, each half being sheeted with glass so that the disposition of the charge could be followed. It was found that segregation of the charge occurred, coarser pieces collecting at the center and periphery with an annular layer of fines between. On increasing the diameter of the bell equivalent to a change from 13 feet to 15 feet full size, the fines collected at the outside with lumps within. This would facilitate the passage of gases through the charge. On making the corresponding change on the actual furnace, the coke consumption fell from 23.94 cwt. to 22 cwt. per ton of pig iron. The fines formed an adherent carbonaceous lining to the furnace, which had a protective effect, and also contributed to fuel economy by diminishing radiation losses.—Note in *Jour. Soc. Chem. Ind.* on a paper by T. C. HUTCHINSON before the Iron and Steel Inst.

No Limit to Inventions and Discoveries

I HAVE been engaged in engineering work, mainly electrical, for nearly forty years, during which time the entire electrical industry may literally be said to have had its birth and development—the telephone, electric light, electric motor, trolley cars, wireless telegraphy, wireless telephone, electric transmission of power—all these have appeared since my first youthful venture in electrical work.

Now on a number of occasions, during these forty years, a lull in new inventions and discoveries seemed to have come about; and on such occasions I have talked with eminent engineers and inventors who all agreed that there was nothing more of importance in our line to be discovered. This conviction was strongest about thirty years ago; fairly strong about twenty years ago; a little weakened but still existing fifteen years ago, but now is a dead doctrine. I have had no such discussion for over ten years and do not expect to have another so long as I live, for facts have been against that theory, and of course facts are such stubborn things that theory which contradicts facts must be abandoned. —From an address by E. W. Rice, Jr., President of the General Electric Co., and of the Am. Ins. of El. Engrs. to a class of graduating students.

Natural Gas Used for Lighting at Pisa

SOME years ago at a farmhouse of Agnano, at a distance of less than two miles from Pisa, a boring was made, says Professor Luiggi, with the object of raising water for domestic and agricultural purposes. No water was struck, and a gas jet burst forth from the borehole. The gas was found to be combustible and it has been used since to supply gas lamps in the locality and district. Owing to the present scarcity of coal, the price of which has risen to fantastic heights, this modest attempt of lighting a township with natural gas attracted the attention of a well-known chemist of Pisa, Dr. Sivieri, Director of the Piombino Smelting Works, who was anxious to ascertain whether there existed in the locality a source of natural gas similar to those met with in petroleum bearing districts, small counterparts of which are found in the Pistoia Appenines, at Salsomaggiore, Sassuolo, Tocco di Casauria and other places in Italy. With that end in view, Dr. Sivieri had more borings made, using steel tubes 3 inches in diameter, which were driven down to a depth of 130 feet to 250 feet. The surface consisted of a layer of vegetable mould, and below that, to a depth of 98 feet, fine compact clay was encountered, below which was a 3-foot stratum of peat, followed by peaty sand and pure sand, down to the depth of 250 feet. The tubes had scarcely reached the peat stratum when abundant gas jets issued forth, which on analysis revealed the following components:

	Per Cent
Methane or marsh gas	85
Hydrocarbons	2
Nitrogen, carbonic acid and other gases	13

In the ordinary burners, this gas gives a weak flame, but when using a gas mantle, a most brilliant light is obtained; its calorific value is 9,000 calories per cubic meter (1,000 B. T. U. per cubic foot), or about double that of ordinary lighting gas. The gas issues from the bore tubes at a pressure of 1 atmosphere to 1.5 atmospheres, and by connecting together the various borings, the supply was found to reach a total of several thousand cubic meters per day. The tubes have since been connected by a suitable main to the Pisa gasholder, where the natural gas pressure is reduced to the ordinary pressure, and whence it is distributed for lighting and heating throughout the town of Pisa. Six tubes are thus connected up and are sufficient for the present needs, but work is in progress for adding 12 more tubes, which have been sunk at different parts of the locality. The district from which the natural gas is tapped has an area of about 5 sq. km. (about 2 square miles). This natural gas, which has, as stated above, approximately double the calorific value of coal gas, can be sold for less than a third the present price of the latter; this means a large saving both for the inhabitants of Pisa and for the national treasury. The question naturally arises as to how long the natural supply will last. Judging from the experience at the Agnano farmhouse, and considering the very high pressure at which the gas issues from the bore tubes and also the wide extension of the peat stratum from which the gas originates, the supply can be expected to continue for several years, when it will exhaust itself as in the case of similar tappings in Pennsylvania. In any case, there is an abundant supply for the present, more than is sufficient for Pisa and the neighboring townships, and it is proving of great advantage.—*Engineering.*

Reactions Between Solid Substances

THE old dictum that substances will not react with one another, except when in the fluid condition, seemed to be rudely shaken, when Walthére Spring, of Liége, demonstrated more than 30 years ago, that neutral salts like sodium carbonate and barium sulphate underwent mutual decomposition (into BaCO and Na_2SO_4), when the dry salts were disintegrated and mixed, and the mixture was exposed to pressures of several thousand atmospheres. There was the obvious objection, however, that the solids might have been liquefied by the heat, resulting from the compression, especially considering that the pressure between the solid particles would hardly be uniform, as in hydrostatic compression, but that locally very high shearing stress might be set up. In that case, the reacting bodies might melt and would, after all, be fluid, and the further consideration that it seems to be almost impossible to exclude all traces of moisture from powdered salts, and that all bodies seem to be volatile to a certain extent—which may be very small—would only confirm the old dictum. That, in fact, appears to be the modern view of the problem. Carey Lea showed, in 1891, that high shearing stress, produced by grinding the substances in a mortar, was more powerful, apparently, to produce reaction than ordinary high pressure and even heating. On the other hand, Perman obtained certain combination effects simply by mixing dried powders; mixtures of colorless salts then showed the colors characteristic of the decomposition products, which had evidently been formed in the vapor state. When, in 1914, Dr. Leslie H. Parker took this investigation up in the Imperial College of Science, South Kensington, he demonstrated the latter point in a simple way. He placed a shallow cup, filled with potassium iodide, KI (practically non-volatile), and another charged with mercury chloride, $Hg\ Cl_2$ (volatile) next to one another in a desiccator jointed to an air pump. Both the salts are colorless, but the KI turned red in 15 minutes in the slightly-heated vessel, because a film of red HgI_2 formed on it, while the $HgCl_2$, which was not assailed by vapors from the KI in the other cup, remained colorless in its own cup. Parker studied particularly reactions produced by trituration, i. e., by grinding dry powders together, experimenting with nitrates, acetates, chromates, etc., of alkalis, silver, lead, etc., under conditions which would yield colored decomposition products, and he easily obtained distinct evidence of reactions due to the shearing stress. But, like Spring, he sometimes observed that a decomposition seemed to continue after a cessation of the stress. Thus, Na_2CO_3 and $Ba\ SO_4$ were dried, mixed and ground for 30 minutes. Immediately after grinding, a decomposition amounting to 2.4 per cent of the mixture was observed. Seven and 14 days later the decomposition had affected 2.5 and 2.7 per cent. It looked, therefore, as if the materials were fused under the shearing stress, and resumed the solid state—in a few cases, at any rate—very slowly, so that the reaction could continue after removal of the stress. The question now arose: Which is the chief agent concerned, the heat or the fusion? If it merely be the heat, the velocity of the reaction should continue to increase, as the temperature is raised; if fusion be the essential factor, the velocity of reaction should also increase with the rise of temperature, but should increase much more rapidly as soon as the melting point of the mixture be reached. Parker's most recent researches (Journal of the Chemical Society, May, 1918), decidedly speak for the fusion effect. In these experiments the salt mixtures were only heated, not compressed. The relations are, no doubt, complex; in the case of the experiments with silver nitrate and sodium carbonate, *e. g.*, there would, in the partly-fused mixture, be present four solid phases, and one liquid and one gaseous phase. But the importance of fusion—as distinct from the thermal effect—seems clearly to be established. Regulation should also be taken into consideration, especially in the cases of ice and bismuth, and our readers will remember the experiments of the late Sir W. Roberts-Austen on the diffusion of one metal into another; one of his metals was fused or hot, however. Lastly, it has often been suggested that metallic atoms will travel at particular rates through other metals with the electric current, when the current is applied to an alloy or to a gold plate which is pressed against a plate of antimony, *e. g.*; but when Sir J. J. Thomson lectured on the thermal conductivity of metals in May, 1915, he stated that he had failed to obtain any trace of such atomic movements.—*Engineering.*

A Screen Which Transmits Radiations Proportional to the Average Visibility Curve

IN certain investigations it is often desirable to use a screen which is opaque to all the infra-red and ultra-violet radiations and which transmits the visible radiations in proportion to the visibility curve of the average eye. Such a screen would be especially useful in a physical photometer, in radiant luminous-efficiency measurements, etc.

The transmission of light through a solution of certain inorganic salts in water forms a convenient and quite accurate copy of the visibility of the average eye. Various combinations of salts have been proposed, the most recent being by Ives and Kingsbury. As already mentioned, the concentration of salts recommended by these two investigators gives a transmission curve which coincides very closely with the visibility curve of the average eye except in the green. The object of the present paper is to describe a modification of the above solution which gives a transmission screen which coincides more closely with the visibility curve of the average eye. The lack of coincidence in the blue is of minor importance.

This solution has the following composition:

Cupric chloride ($CuCl_2.2H_2O$)	grams	5.7
Cobalt ammonium sulphate [$Co(NH_4)_2(SO_4)_2.6H_2O$]	"	1.2
Potassium chromate (K_2CrO_4)	"	0.16
Nitric acid (HNO_3)	"	0.123
Water (H_2O)	mols (cc)	100

The salts were analyzed for purity. The nitric acid is expressed as 100 per cent acid (equivalent to 1.3 cc. nitric acid, specific gravity 1.05 at 15°/4°).

This solution is to be used in a glass cell 1 cm. in thickness with uncolored glass windows. An additional cell of water 3 to 4 cm. in thickness is to be used to absorb the infra-red rays. To reduce reflection losses these two cells may be placed in contact with a film of glycerin intervening, the edges being covered with paraffin. The maximum transmission of this (double) cell was found to be 61 per cent at 20° C.

The transmission of the separate constituents was determined, and from this the proper concentrations for matching the visibility curve were estimated. In view of the fact that the "computed" and "observed" transmissions at 20° C. are in exact agreement for the mixture of the salts they can be used in a single cell, although one would naturally expect to use the constituents in separate cells. The visibility curve is 1.2 per cent larger than the superposed (at 0.56μ) transmission curve of the screen between λ=0.44μ and λ=0.72μ. —From a paper in Bulletin of the Bureau of Standards, Vol. 14, No. 2 on Relative Sensibility of the Average Eye to Light of Different Colors and Some Practical Applications of Radiation Problems, by W. W. COBLENTZ and W. B. EMERSON.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, AUGUST 10, 1918

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President
Secretary; Orson D. Munn, Treasurer
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

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The Scientific American Publications

Scientific American Supplement, (established 1876) per year $5.00
Scientific American (established 1845) " 4.00
The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check.

Munn & Co., Inc., 233 Broadway, New York

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